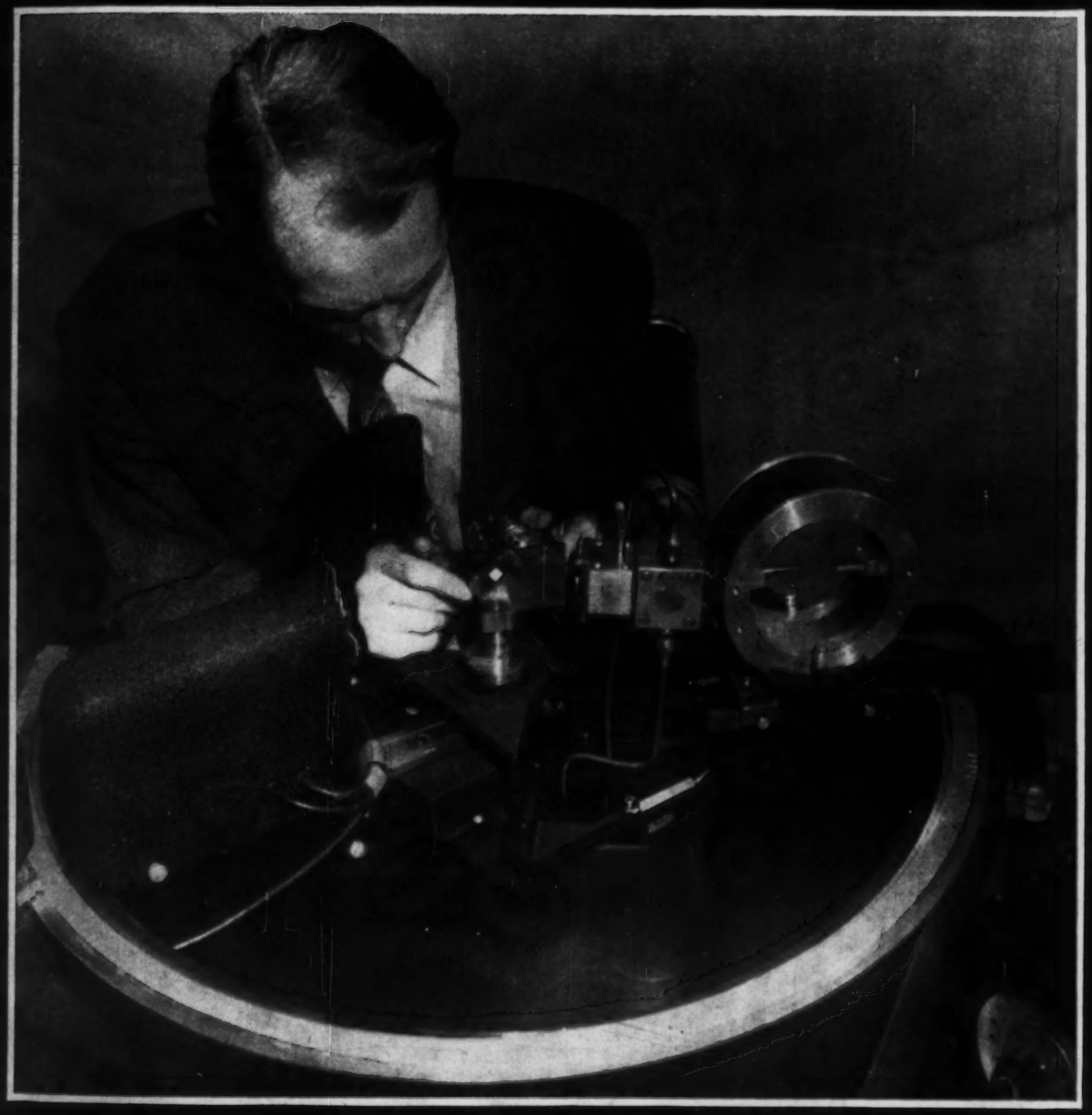
Instruments

THE MAGAZINE of MEASUREMENT and CONTROL

Vol. 21 MAY 1948 No. 5

Including the *JOURNAL* of the Instrument Society of America



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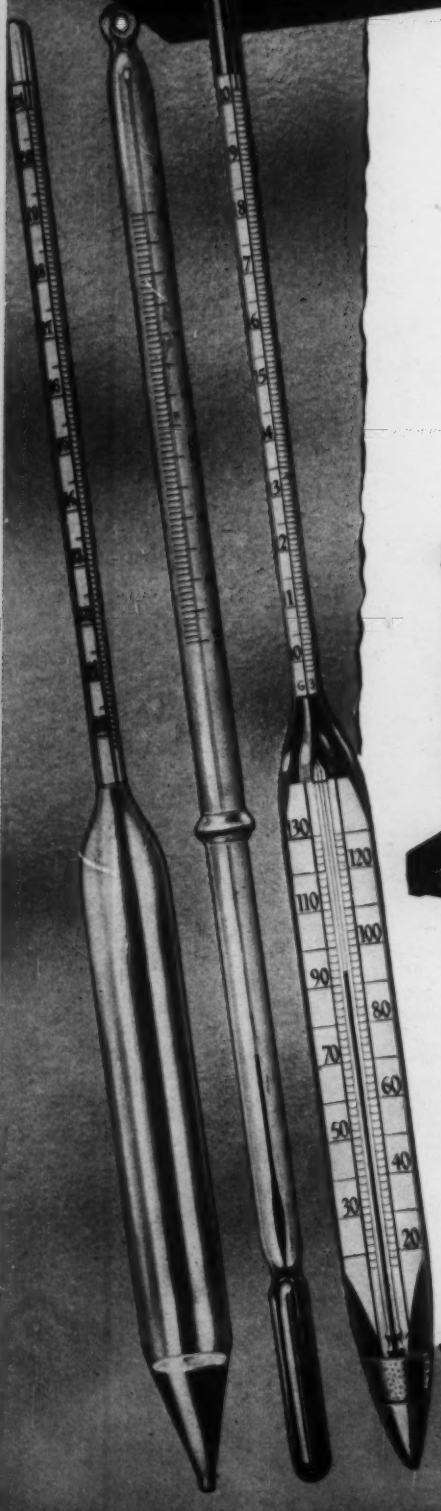

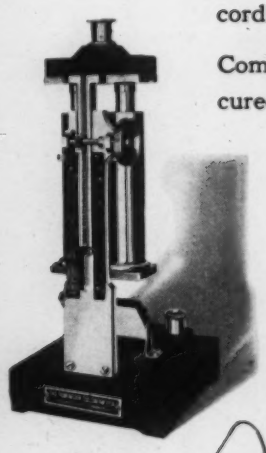

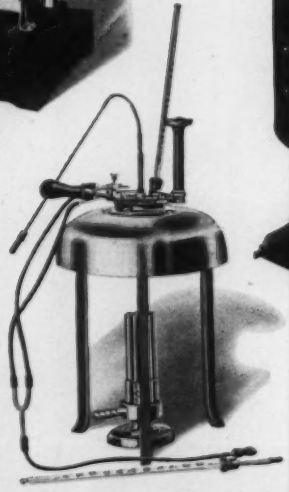

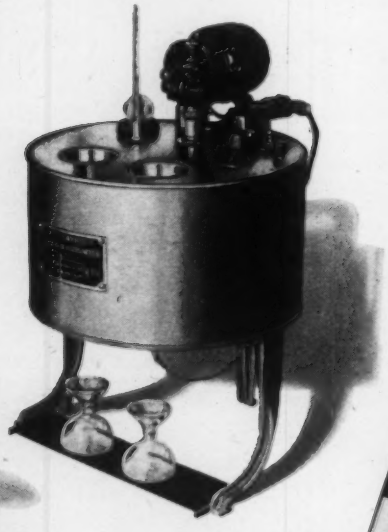

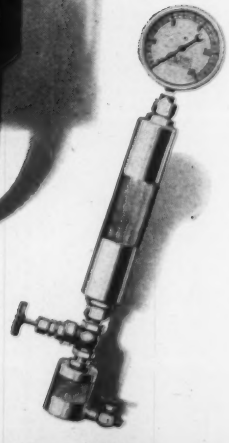

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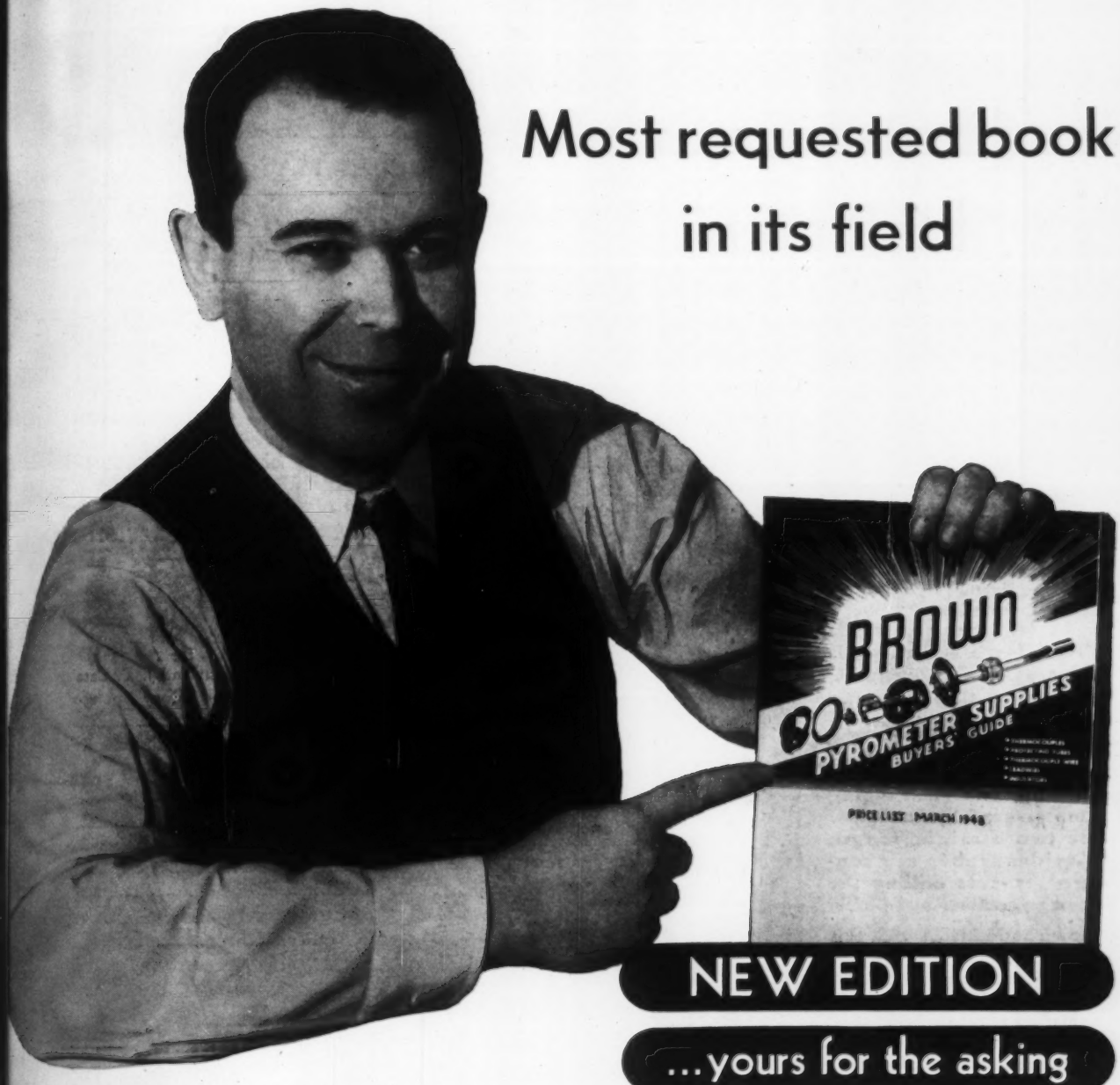

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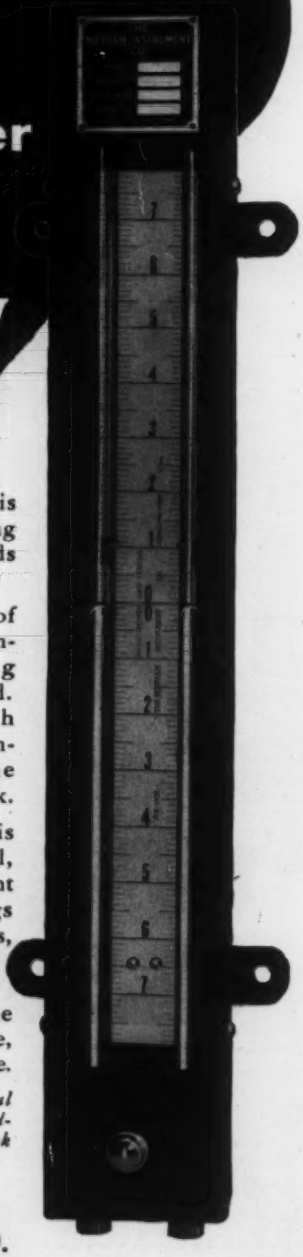

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Instruments

Vol. 21 MAY, 1948 No. 5

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If you want IMMEDIATE records of strains...

● Here's a strain measuring device that produces records immediately for interpretation. The "STRAIN ANALYZER" consists of a Model BL-310 Strain Amplifier and the Brush Direct-Inking Oscillograph. It's completely self-contained, requiring only two external strain gage connections, one dummy gage and one active gage cemented to the piece being tested.

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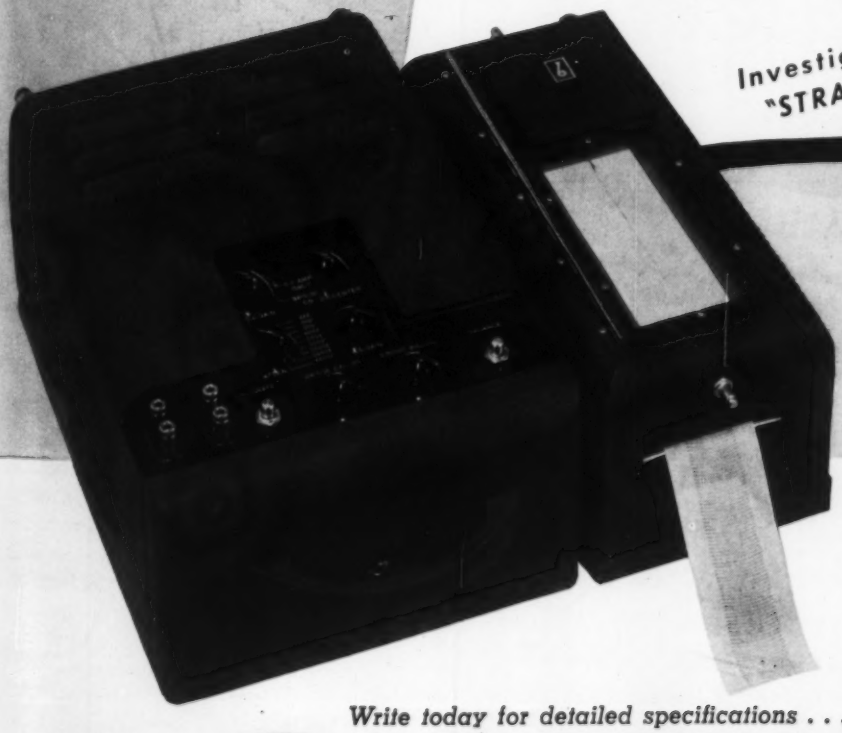

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PRODUCTION REQUIREMENTS FOR BOURDON TUBING

by Charles T. Flachbart,
Chief Engineer, Precision Tube Co.

The most important feature of Bourdon Tubing is the exact duplication necessary from piece to piece, from shipment to shipment. This exactness calls for special attention at many points in the manufacturing process. In certain materials, the tubular stock for Bourdon Tubing is machined immediately after the billet is pierced. This eliminates surface inclusions and establishes concentricity. In drawing operations which follow, the material must be kept off the floor or other places where dirt might be picked up. All machines must be kept clean. Fresh lubricant is specified for every run, and it is continuously filtered or otherwise cleaned. Tool wear is checked and compensated for at every step.

Annealing is a vital step in production. Grain growth must be controlled, and structure of the metal must be sound in every respect. Here at Precision, each anneal of every job is completely specified by the Laboratory. Samples are taken before and after every step of every Bourdon job, and a permanent file is kept. This file shows the complete sequence of every Bourdon run, along with information of hardness, metallography, annealing specifications, and other pertinent data. The file is consulted regularly by Production, Methods, and Engineering Sections requiring exact information in planning new work. A certified report is prepared on the finished material for each Bourdon order. This report is entered in a confidential file, and copies are available for each customer, upon request.

Care in manufacture cannot be overemphasized. At the same time, accurate records are also essential. Other requirements are the machines to duplicate exactly what has been done before, and the experience to interpret specifications in terms of procedure and tooling. While these same requirements apply to some extent in all manufacturing, they are especially important in Bourdon production. The ideal combination is a well equipped mill with considerable experience in precision work, having a special department devoted to Bourdon Tubing. The Precision Tube Company qualifies.

A British Report *on* German Industrial Instruments

"Instrumentation and Control in the German Chemical Industry—A Report of the British Intelligence Objectives Subcommittee," by C. H. GREGORY, H. B. APPLETON, A. P. LOWES and F. C. WHALEN. Reproduced (by photo-litho) by permission of the Controller of His Majesty's Stationery Office and by arrangement with the Office of Technical Services, U. S. Dep't of Commerce. Mapleton House, Brooklyn 4, N. Y., 1947. Paper binding, 5¼" × 7⅞", 158 pages, Price $6.00.

BOOKS made up of reduced-size reproductions of typewritten pages strain human eyes. This one is no exception. As a manufactured book it's worth sixty cents, we think, rather than six dollars. As a report, all of it may be valuable to some *Instruments* subscribers and a few portions of it may be of interest to all *Instruments* subscribers. Therefore, the most interesting information contained in the report (interesting to instrument USERS) is given below, mostly in word-for-word quotations.

Forty-one "targets" were visited: twenty-three chemical plants and eighteen instrument firms.

From the blanks in the table it is obvious that the report's value would have been greater if the same items of information had been obtained in all of the twenty-three chemical plants visited. It would have been more interesting, also, if a list of all instrument TYPES used in each chemical plant visited had been included, as well as the NUMBER of each type. The authors state that "at many of the targets little information was obtained because some of the factories were badly damaged; in others the key personnel were not available. . . . In view of the limited period [April 12-June 12, 1946] it was not possible to spend much time at each target . . ."

The authors state that the two I.G. plants, at Leuna and at Schkopau, "are probably two of the best instrumented factories in Germany but unfortunately it was not possible to cover them." (In the Russian zone.)

Fifty-five drawings are included, some of them full-page and all others half-page. Nowhere do the authors state "better than what we've got," but they seem to be fascinated by some designs. They devote five drawings to one system of liquid-level control at high pressures. This system is shown below (with graphic symbols and verbal legends redrawn and re-worded in American). Our subscribers will find this system interesting—perhaps "fascinating" . . . !

This English report reminds us to remind Program Chairmen that J. C. Peters (L&N) and E. D. Haigler (Foxboro) can both give really fascinating talks, with 150 color-photo slides, on the trips they made in Germany for the U. S. Government. —M. F. BEHAR

"Target No."	Company and Location	Products	Total No. of employees (when on full production)	Instrument Dep't empl. (when on full production)	Cost of instruments compared to plant cost
12	Ruhr Chemie A.G., Obenhausen-Olten	Ammonia, Fisher-Tropsch Process products, etc.	4000	140	5%
37	Hydriewerke Scholven A.G., Gelsenkirchen-Buer	Coal hydrogenation		200	
24	I. G. Chemische Werke, Huels	Synthetic rubber, acetylene, solvents	10,000	279	5%-10%
40	I. G. Farbenindustrie, Hoechst	Pharmaceuticals			
19	Union Rheinische Braunkohlen Kraftstoff A.G., Wesseling	Coal hydrogenation	3500	150	3%-4%

("TARGET No. 12")

Instrument Department responsible for purchase, installation and maintenance of instruments.

("TARGET No. 37")

Instrument Department divided into three sections:

(1) *Factory maintenance*, which carried out routine maintenance and calibration of instruments.

(2) *Instrument Shops*, where major instrument repairs were made.

(3) *Records Office*, where flowmeter charts were integrated and plant balances prepared.

("TARGET No. 24")

Head of Instrument Department responsible to Works Production Manager (at one time responsible to Chief Engineer but this arrangement not considered satisfactory). For organization purposes, Instrument Department is divided into two:

1. *External Department*, responsible for maintenance of instruments in the factory which is divided into six sections: gas, organic and buna, inorganic, ethylene, services and power plant with an engineer in charge of each section. (For some reason, section merger of power plant is responsible to power plant engineer, and not to factory instrument manager.) Factory Section instrument managers, who are interchanged periodically for experience, have a general responsibility. One is in charge of the instrument laboratory for the whole plant; another is responsible for ordering and purchasing of new instruments and for contacts with instrument manufacturers, another is responsible for taking all records, another has a small development section which studies general problems and another investigates plant flows if there is dispute.

2. *Internal Department*, also divided into six sections:

I. Shop—This section is subdivided into (*a*) general shop where orifice plates and other instrument parts are made and control valves overhauled; (*b*) mechanical shop which repairs and recalibrates instruments; (*c*) precision shop where fine instrument parts are made; (*d*) clock repair shop; (*e*) electrical shop for repair and calibration of electrical instruments.

II. Physical Laboratory where all physical measurements, i.e., viscosity, density, expansion coefficients, etc. required for plant control are made at the request of plant chemists. Also responsible for proper functioning of all analysis instruments.

III. Spectroscopic Laboratory makes analysis of gases and metals.

IV. Drafting Room is concerned with changes in instrument layouts, design of panels for small additions, alterations in design of instruments for particular applications, calculation of orifice plates, etc.

V. Records and Statistical Office planimeters charts and applies correction factors, completes plant efficiency forms.

VI. Positive Meter and Orifice Plate Repair and Calibration Section.

("TARGET No. 40")

Instrument manager stated most important work of instrument departments is the general study of application of measurement and automatic control. Instrument department divided into five sections:

1. Chemical Engineering. Investigation of general engineering problems such as distillations, controllability of plants, etc.

2. Instrument Shop. Major calibration and repairs.

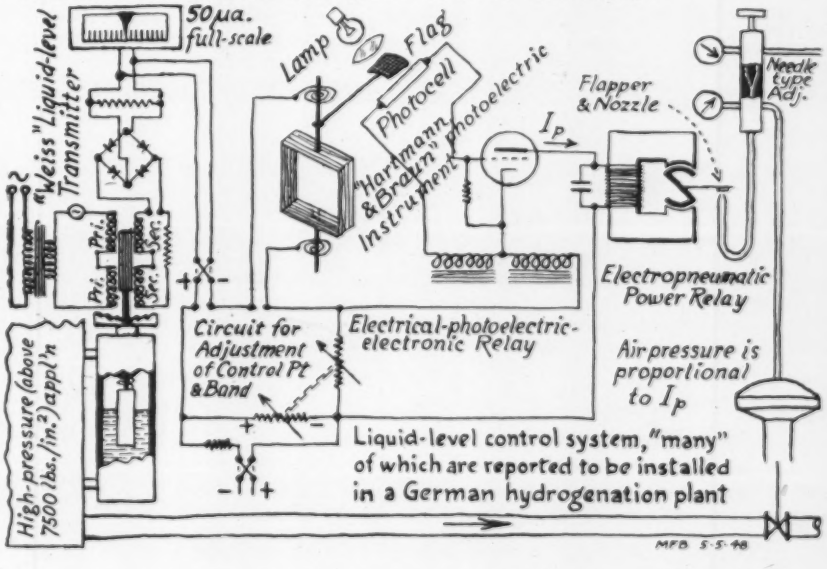
3. Glass Blowing Department.

4. Maintenance Section responsible for maintenance of all plant instruments.

5. Physics Laboratory carries out physical measurement for whole plant.

("TARGET No. 19")

[The report states only that "the instrument organization at Wesseling followed Oppau practice" (meaning the practice at I. G. Farbenindustrie, Oppau) but the report does not give any information on the instrument department *organization* at Oppau: it deals rather with personalities. The reasons for this emphasis probably are: (1) That Dr. Witte, Instrument Manager at Oppau and a famous expert on flow measurement, was not in good health when he was interviewed; (2) That Dr. Ernst, who is responsible for the design and development of instruments required by all the I. G. factories, was absent.]



The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.
FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 475

Watthour Meter

New "Type I-50," announced as "the first completely new watthour meter in 50 years," represents more than ten radical innovations, chief of which is magnetic suspension, Fig. 1: two con-

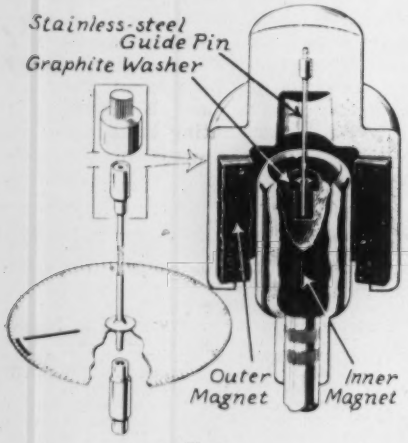


Fig. 1

centric magnets magnetized axially and with opposite polarities support disk-and-shaft assembly in equilibrium. Magnets are of Cunico, a new alloy of high coercive force. With this new suspension, torque-to weight ratio—long accepted as being 3 or 4 to 1—has been increased to infinity. Disk-and-shaft assembly is kept in vertical alignment

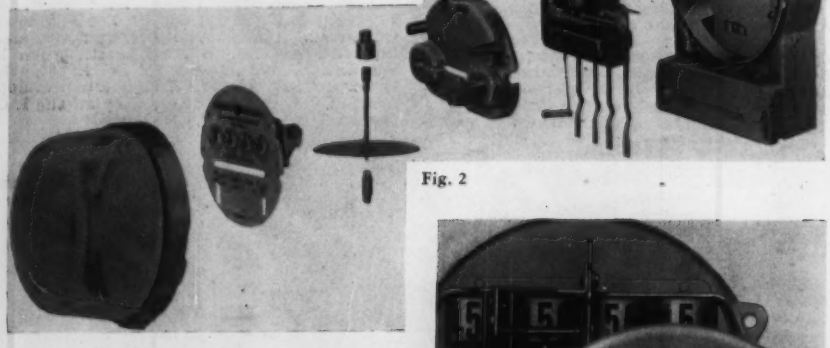
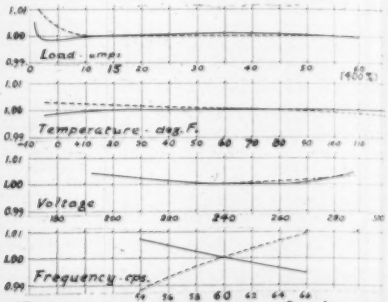


Fig. 2

by graphite washers at top and bottom, riding against stainless-steel guide pins: no lubrication ever required and, since usual side thrust is minimized by new damping arrangement (described below), local pressures between washers and guide pins never exceed 100 lbs./in.^{2}, which is 1/2000 of value of local pressures (200,000 lbs./in.^{2}) in conventional-design jeweled bearings that support moving elements. New damping arrangement is radical departure from conventional meter design where electromagnet is mounted in back of frame and disk shaft and damping magnet at front of meter: instead, damping-magnet poles are located so close to re-designed electromagnet that they create practically no net side thrust. Electromagnet itself is completely new: die-cast into frame which provides alignment and support for all operating parts, register and moving element as well as electromagnet. For the first time, current coil is molded directly to core (butyl rubber providing turn, coil and ground insulation). Layer-wound potential coil is molded to core (molding material a polyethylene plastic of high dielectric strength and low moisture absorption). In socket-connected meter, unit molded base replaces conventional built-up assembly, provides coördinated insulation. In bottom-connected meter, all exposed parts of base are aluminum. Controlled air gap between current-coil leads and ground pins has breakdown level of between 4000 and 5000 volts; this relief gap directs overvoltage away from electromagnet to ground; breakdown level of gap is lower than that of current or potential coil, result is added protection to meter from surges. Calibration and factory adjustments represent innovations, made possible by new designs of all meter components, contribute to assurance of calibration stability in service. Register is furnished as either pointer type (Fig. 2) or cyclometer type (Fig. 3), latter with number cylinders on vertical shafts to minimize friction and with a new feature employing storage and release of



Average Accuracy Curves of the Single-phase Type I-50 rated 15 amps., 240 volts, 60 cps., 3-wire
——PF 1.0 -------PF 0.5 lagging

Fig. 4

energy to give positive reading action. New design features and new materials combine to assure accuracy (Fig. 4). Development of this meter began before World War II; maker's scientists, engineers and technicians have worked 353 man-years on it; life tests on 194 meters with magnetic suspension were started in 1941 and helped determine final choices of materials and final designs now announced.—*Meter and Instrument Div., General Electric Co., 40 Federal St., West Lynn, Mass.*

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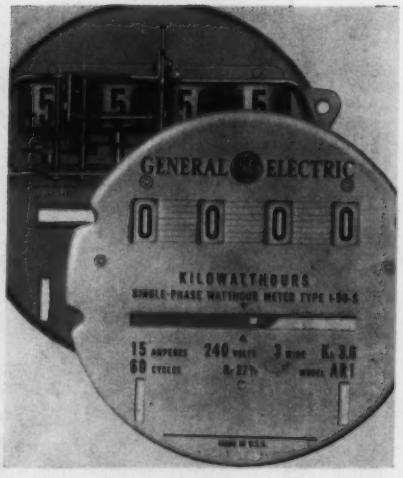

Fig. 3

Liquid-filled System for Temperature Instruments

New organic-liquid-actuated thermal system is particularly adaptable to applications where: (1) a small bulb is required; (2) short range intervals are desirable; (3) manufacturing process is sensitive to mercury; (4) sub-zero temperatures are encountered. New system utilizes a single-bore capillary and a single Bourdon spring with a "U"-shaped bimetallic compensator on spring for case temperature changes. Uniform charts are used and new system is available with the usual fittings, armors, etc., as supplied on other thermal systems.—*Taylor Instrument Companies, Rochester, N. Y.*

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Fast-response Resistance-thermometer Bulbs

New resistance-thermometer bulbs are announced, in which resistance elements are metallic wires of exceptional stability. All wires, except platinum, are solidly embedded in glass or fused quartz. Air spaces are completely eliminated. Construction provides a solid path for heat conduction and a short response time. Where maximum speed of response is required, quartz units are recommended as heat conductivity of quartz approaches that of steel. All bulbs are suitable for use with two- or three-wire bridges. Maker will provide flexible low-resistance leads for connection to bridge; also suitable thermometer wells. For high speed of response, bulbs with a heavy coating of metal provided with a pipe thread at one end—a design completely eliminating air spaces. Announcement lists various Pyrex and quartz bulbs, with wires of platinum, exceptionally-pure nickel, etc., for various ranges (up to 1800°F. continuously and to 2200°F. intermittently.—*Paul G. Weiller, 95 Broad St., New York 4, N. Y.*

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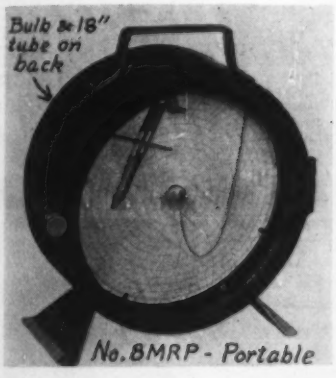
Recording Thermometer

New "8MR" 8" Recording Thermometer is newest addition to maker's line of 10" and 12" recorders, can be supplied for wall mounting, flush mounting and portable use (illustrated) for recording of temperature, pressure or time - of - operation. All - stainless-steel movement provides long life and accuracy. Supplied in all standard ranges, with one- or two-pen systems, and in all standard chart revolutions, both electric or hand wound.—*Dept. EP-7, Weksler Thermometer Corp., 52 W. Houston St., New York 2, N. Y.*



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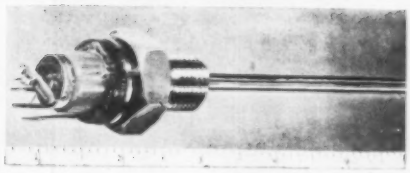
Temperature Transmitter

New "Type 4911 Temperature Transducer" is designed for telemetering applications where space is limited. A temperature - sensitive bimetallic element inside small tube (see illustration) rotates a "Microtorque" voltage divider, so that temperature variations cause output-voltage changes suitable for recording with oscillographs, galvanometer-recorders and telemetering systems. In a typical aviation application, new device supplies ambient temperature at altitude of an aircraft to a telemetering transmitter for reception and recording on ground. Standard resistance 5000 ohms, but resistances are available from 100 to 20,000 ohms. Designed for a temperature range from −65°C. to +150°C., it has linearity of 1%, accuracy of 1%, sensitivity of 1°C. or less, standard response time of 2 seconds.—*G. M. Giannini & Co., Inc., 285 W. Colorado St., Pasadena 1, Calif.*



Please mention number 505 when filling out card

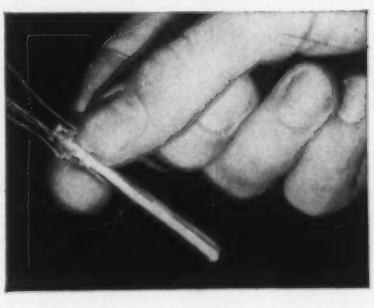
Roll-surface Temperature-measuring System

New "Measuring Head" (primary-element assembly) is announced for accurate measurement of roll surface temperatures of calenders, dryers, and similar roll-type machines; and industrial instruments for recording and automatically controlling such temperatures are available. In operating ranges between −40°F. and +350°F., and at all ordinary operating speeds, continuous temperature measurement is assured within 2° and even higher accuracy is possible in individual installations, depending upon conditions. New measuring head is a small box-like unit, faced with low-friction material and containing a tiny but durable resistance element contacting a T-shaped spring of thin stainless steel, chromium plated. Pressure against machine roll is constant and sure, but so light that no marking of equipment or goods is produced. Measuring head is connected by 3-wire cable of any length with "Dynalog" temperature recorder, with which a "Model 40" controller, of any control-action type desired, may be combined.—*The Foxboro Co., Foxboro, Mass.*

Please mention number 506 when filling out card

Low-temperature Platinum Resistance Thermometer Bulb

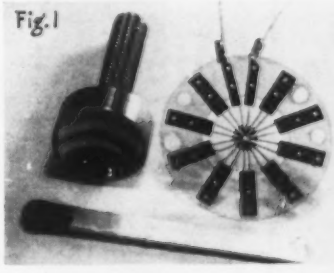
New "thimble-size" platinum resistance thermometer bulb is for such work as calorimetric measurements at extremely low temperatures—in the region of 10°K. and higher. Based on a design by Dr. H. J. Hoge of NBS, it is only about one-eighth the size of maker's standard high-precision platinum thermometer although it uses the same temperature-sensitive element. It has a platinum protecting tube about 48 mm. long and 5.6 mm. outside diameter, and can be readily mounted entirely inside a calorimeter by casting in low-melting alloy. It is helium-filled, and therefore usable down to approx. 5°K. Four-wire current and potential leads are brought out through a glass seal. Nominal resistance at 0°C. is 25.5 ohms. New device can also be employed as a primary standard for resistance thermometry between −190 and 500°C. and can be supplied with or without NBS certificate for that range. When used with Type G-2 Mueller Bridge, accuracy is ±0.01°C. in the calibrated range.—*Leeds & Northrup Co., 4934 Stenton Avenue, Philadelphia 44, Pa.*

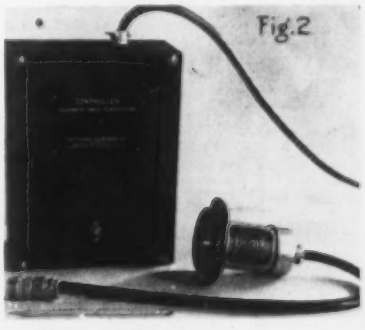


Please mention number 507 when filling out card

Low-temperature Radiation Pyrometer

New low-temperature radiation pyrometer makes possible accurate control of low-temperature processing. Equipments consists of: (1) A low-range "Radiamatic" head designed for optimum sensitivity in the region of longer wave-lengths encountered in temperature under 1000°F. Two essential parts are shown in actual size in Fig. 1: concave first-surface mirror and thermopile. Measuring junctions of thermopile are at center. (2) A control box to control temperature of reference junctions at periphery of "Radiamatic" head, plus thermopile reference junctions, at 120°F. It maintains reference-junction temperature constant to a fraction of a degree. (3) Maker's "Electronik" circular- or strip-chart recorder — with control features if desired—with a special measuring circuit for use with low-range "Radiamatic" head. New system will respond to temperature changes of one or two degrees F. within the span of ambient temperature to 212°F.





It is offered as an uncalibrated unit only, since any calibration would depend upon its use under blackbody conditions or on a target of known emittance. On most applications, ability to control a process and maintain product quality is of much greater importance than knowledge of true temperature. Sighting tubes or other sight-limiting devices will be tailored to an application. Conditions favorable to successful

operation are: (1) Work temperatures between ambient and 1000°F., preferably the lower temperatures. (2) A relatively high emittance—in any event it should remain constant within a small percentage of its nominal value. (3) Ample sighting area—full target area is a 3½" diameter circle at 12" from the lens; other target areas in accordance with same ratio. (4) Ambient temperature surrounding "Radiamatic" head always below 120°F. and not subject to rapid fluctuations.—*Brown Instrument Co., 4482 Wayne Ave., Philadelphia 44, Pa.*

Please mention number 508 when filling out card

PVT-laws System for Measuring Gas Temperatures to 5000°F.

New "Unit 263 Laboratory Gas Temperature Indicator" utilizes continuous-sampling method but differs radically from nineteenth-century aspiration pyrometers in that cooling is accomplished with compensation for all important sources of error including error-sources neglected in every older system. Fig. 1

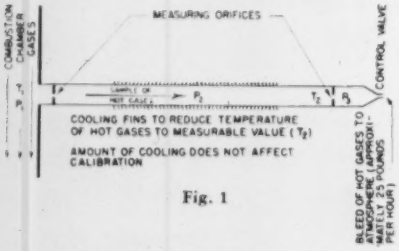

MEASURING ORIFICES
COMBUSTION CHAMBER GASES
CONTROL VALVE
COOLING FINS TO REDUCE TEMPERATURE OF HOT GASES TO MEASURABLE VALUE (T_2)
AMOUNT OF COOLING DOES NOT AFFECT CALIBRATION
BLEED OF HOT GASES TO ATMOSPHERE (APPROXIMATELY 2 POUNDS PER HOUR)

Fig. 1

is a schematic diagram of "Fairchild Pneumatic Gas Temperature System" on which new equipment is based. Actual design and construction make troublesome variables cancel out (for complete mathematical presentation see paper by D. W. Moore, 1947 meeting of Institute of Aeronautical Sciences). Fig. 2 shows

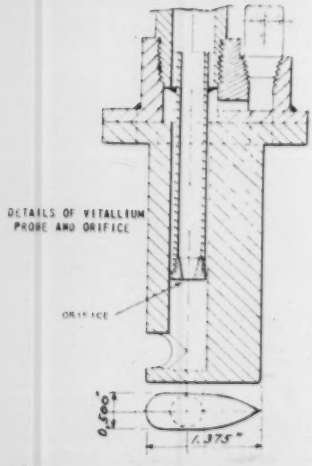
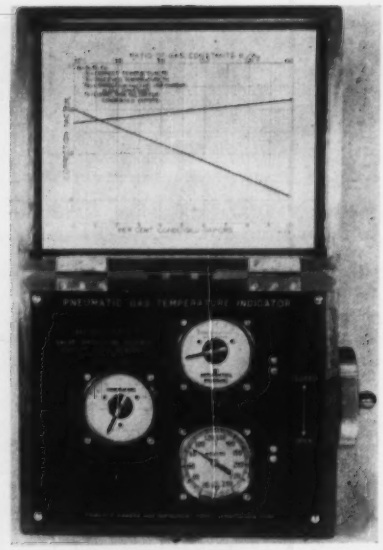


Fig. 2

one type of probe. Probes of suitable metals are furnished for temperatures to 2300°F. and water-cooled probes with iridium orifices are furnished for temperatures to 5000°F. Probe diameter, length and shape are tailored to customer specifications. Equipment is simple in operation and ruggedly constructed for laboratory use. Insertion of a probe into gas stream and operation of a single control valve on instrument case is all that is required to obtain gas temperature measurements. Accuracies of 1% are guaranteed up to 2000°F. In

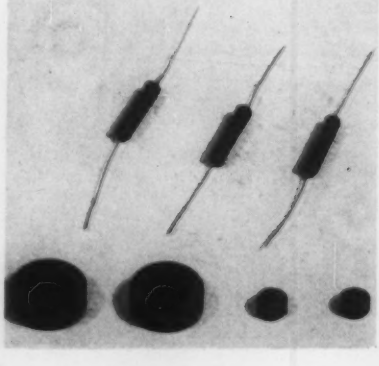


2000-5000°F. range, reproducibility of ±2% is guaranteed. "Unit 263 Indicator" is especially suited for use with gas turbines, turbo jets, ram jets, rockets and general industrial laboratory use; also for determining applicability of new system as a temperature-responsive control or temperature-limiting device for incorporation in various types of equipment. Instruments are available two months from receipt of order.—*Engine Control Div., Fairchild Camera and Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, N. Y.*

Please mention number 509 when filling out card

Thermistors

New line of thermistors (electrical semi-conductors that respond to temperature variations as small as 0.001°C.) is announced. Made from mixtures of semi-conducting metallic oxides and possessing a high negative temperature coefficient, they are available in the form of rods, disks, and beads. They are said to be especially adaptable as sensitive elements in flowmeters, time delay relays, switching devices, etc. Since they are pure electrical resistances, they can be used with either a-c. or d-c. They may be actuated either by ambient temperatures or by internal heating. Systems employing G-E Thermistors permit temperature variations to be transmitted automatically to distant locations, as in meteorological work to enable one operator to study several different temperatures at once. Their negative coefficient of resistance may be used to offset positive coefficient of conventional

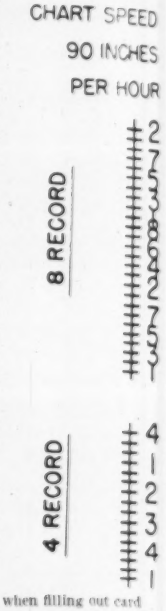


electrical conductors ("copper error") in instruments, meters, etc., to correct errors caused by ambient temperature variations. Makers recommend their use as precision elements in aircraft engines, chemical and food processing equipment, air conditioning systems, and domestic appliances. — *Metallurgy Div., Chemical Eng'g Dep't, General Electric Co., Pittsfield, Mass.*

Please mention number 510 when filling out card

Print-wheel for Multiple Recording

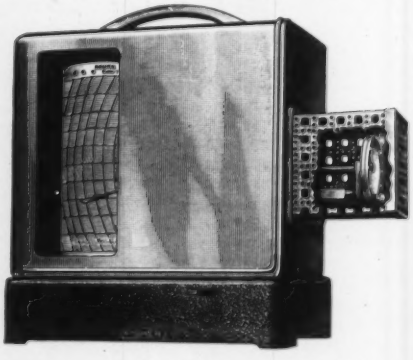
New improved skip-numeral print wheel, when used with makers' strip-chart "Electronik" recorders, permits symmetrical and well-defined multiple measurement records. It overcomes a crossing of records and superposition of numerals of any one record. It utilizes same basic system of plus and numerical identification; also staggers numeral locations for different records, permitting use of slower chart speeds and thereby effecting a substantial chart economy.—*Brown Instrument Co., 4482 Wayne Ave., Philadelphia 44, Pa.*



Please mention number 511 when filling out card

Recording Hygrometer

New Recording Hygrometer is claimed to be more accurate and rapid in response than previous instruments of this type: is accurate within ±3% in

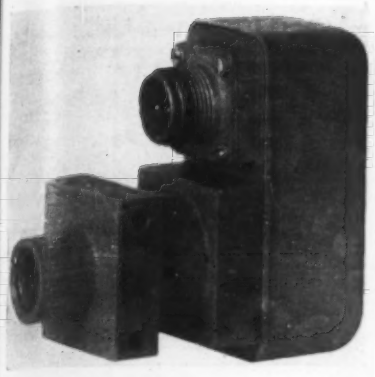


the range of 15% to 100%. It incorporates a sensitive hygroscopic diaphragm connected with a counterbalanced pen which records the changes on a drum chart. It operates for 30 hours without rewinding.—*Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.*

Please mention number 512 when filling out card

Pressure Switch

New pressure switch can be made to operate throughout its range of 100-5000 lbs./in.²;has been designed to all applicable AN specifications; has been granted Yellow Dot approval. Compensated for temperature changes, it main-



tains a constant setting from −65° to 165° (complete data on winterization tests available). Unit operates on oil, fuel, freon, gas or air; is made of dural bar stock; measures 4⅜" × 3-3/16" × 1½"; weighs 10 oz.—*Saval Co., 1915 E. 51st St., Los Angeles 11, Calif.*

Please mention number 513 when filling out card

Pressure-reducing Valve

New "Type E-41 Automatic Valve" is an all-bronze pressure reducing and regulating valve for domestic and in-

dustrial uses. It is available for immediate delivery in pipe sizes of 1¼", 1½", and 2", for pressures up to 250 lbs. Among features: (1) Nickel-chrome-bronze Screwed-in Seat; (2) Stick resisting Hycar seat washer; (3) Yoke type construction; (4) Neoprene seats.—*Cash Acme, 666 E. Wabash Ave., Decatur 60, Ill.*

Please mention number 514 when filling out card

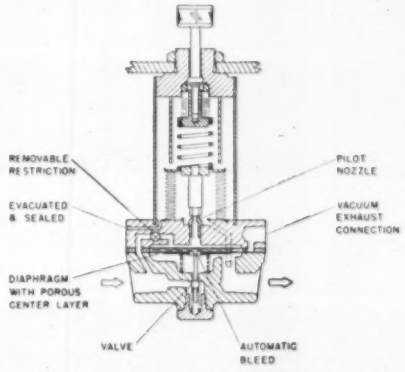
Rough Vacuum Switch

New "S M C I" switch operates at selected points from 26" to 5" Hg. gage, uses positive direct actuation by a bellows and internal construction permits pressures in system up to 50 lbs./in.². Switch, exhaust chamber and exhaust tube are constructed with most rugged components and standard fittings. Entire switchgear is encased in a sealed steel tubing envelope —all moisture and outside plant or laboratory dirt is kept away from externally-actuated valving assembly.—*Skaneateles Mfg. Co., Inc., 122 Dickerson St., Syracuse 2, N. Y.*

Please mention number 515 when filling out card

Absolute-pressure and Vacuum Controllers

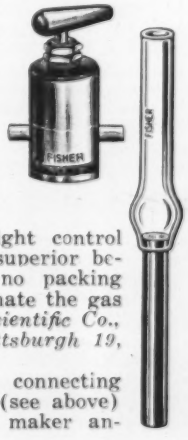
New "Nullmatic Pressure Regulators" for sub-atmospheric applications, include models with barometric compensation for regulating at absolute values; are designed to hold set values constant regardless of changes in flow as well as variations in the supply pressure. They use pneumatic null balance system in which main valve is operated by a pilot nozzle which operates with a constant differential-pressure that holds nozzle seat at essentially the same position for each set value. Two models have an automatic bleed which makes them suitable for use on dead-end service as well as on flow and reverse-flow service. Model



illustrated, suitable for regulating absolute pressures, has an evacuated chamber; other model is not compensated for barometric pressures. Regulated pressure range of these instruments is 1 to 20 lbs./in.²abs. when used on dead-end service, or approx. 0 to 20 lbs. when used on continuous flow service of 0.02 scfm. or more. Two other models are furnished for use on continuous flow applications only; do not have automatic bleed; are suitable for flows of 0.02 scfm. or more. These regulators—an absolute pressure model and a vacuum pressure model, have standard regulated pressure ranges of approximately 0 to 20 lbs./in.²abs. Maximum capacity of all models, with atmospheric supply and critical pressure drop, is approx. 1 scfm.—*Moore Products Co., H & Lycoming Sts., Philadelphia 24, Pa.*

Please mention number 516 when filling out card

Packless Vacuum Valve Kovar-Pyrex Seal

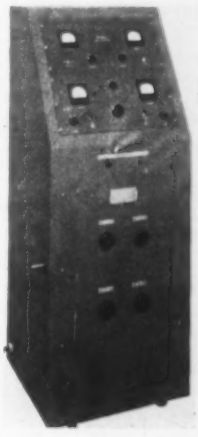


(1) New Packless Vacuum Valve has been introduced for controlling introduction of gases from a cylinder into a glass system. It incorporates bronze bellows and a ball-type closure which permits close, airtight control and is said to be superior because it contains no packing that would contaminate the gas sample. — *Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.*

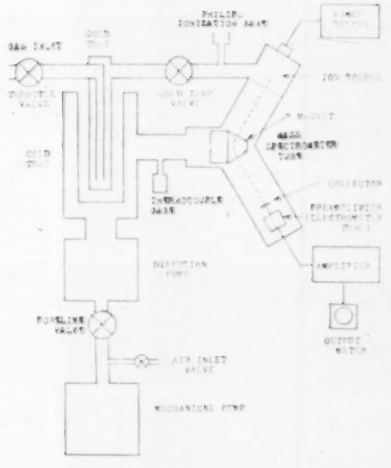
(2) For use in connecting new vacuum valve (see above) to a glass system, maker announces also a Kovar-Pyrex Seal, one end of which can be soldered to the valve and the other of glass connected to any glass system.—*Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.*

Please mention number 517 when filling out card

Mass Spectrometer Leak Detector



New "Veeco Leak Detector" (mfd. under license of University of Minnesota) is designed for leak testing wherever a vacuum, fixed pressure or special atmosphere must be maintained. It is a transportable mass spectrometer, adjusted to analyze a gas for the presence of helium. Mass-spectrometer tube is maintained at a high vacuum by a small vacuum pumping system which is an integral part of detector. Both vacuum testing and pressure testing may be conducted with new detector. In vacuum method, equipment under test is continuously evacuated. A continuous sample of gas in pumping line is passed to detector; a small stream of helium is played over points of suspected leakage, so that, if a leak does exist, helium enters and is present in pumping line and in detector. Gas sample is ionized in mass-spectrometer tube and the positive ions so formed are



sorted so that only helium ions will strike a collecting target. An ion current will then flow from target to amplifier; amplified current deflects a milliameter, indicating a leak. In absence of leakage, no deflection occurs. For pressure testing, helium is introduced within test object under a pressure greater than atmospheric. Helium will then issue from any existing leaks. A suction line connected to detector is passed over suspect points. Any outflowing helium is drawn in and passes to detector, causing a deflection. New detector responds to less than 1 part in 200,000 of helium in air. In terms of leakage, it can flow (from at-

mosphere into vacuum) of 0.00001 std. cc/hr. High sensitivity makes possible detection of small leaks in presence of many large ones. Leakage can be measured quantitatively. Among other features: all operating controls, including valves, on front panel; mechanical section designed for rapid, easy assembly; all-metal construction — no glass to break; fan-cooled diffusion pump—no water required; metal pressure gages, uninjured by exposure to atmospheric pressure; simple operation by non-technical personnel; 115-volt 60-cycle a-c. operation—no storage batteries.—*Vacuum Electronic Engineering Co., 316 37th Street, Brooklyn 32, N. Y.*

Please mention number 518 when filling out card

Vacuum Valve

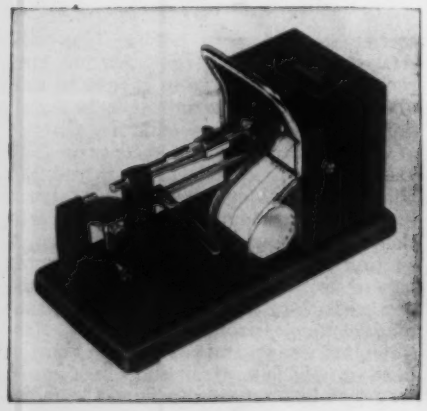
New "SMCI VV-1 Valve" is designed to keep all valve-seating parts enclosed. There is no mechanical movement of

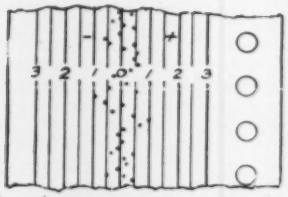
components to atmosphere. Valve uses a simple direct-sealing principle, is non-trapping, has a high area valving seat. Internal design affords full opening, low restriction with a "slam-shut" hydraulic action. Hydraulic internal components are resistant to most acids and vapors. There are no metal surfaces to scratch or pit. Design affords simple, easy servicing and installation operations. Standard size 1"; larger sizes designed on customer specifications.—*Skaneateles Mfg. Co., Inc., 122 Dickerson St., Syracuse 2, N. Y.*

Please mention number 519 when filling out card

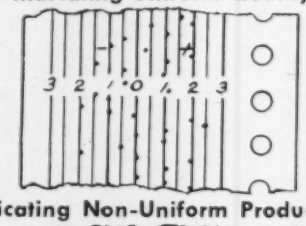
Recording Micrometer

New "Model 500 Recording Gage" measures small parts and simultaneously records, on a tape chart, deviation of pieces from specified dimension. Its special usefulness, therefore, is quality control. A standard micrometer

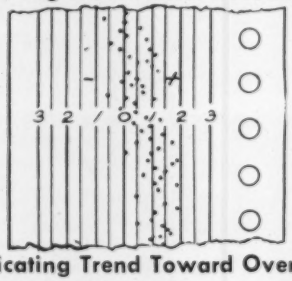




Indicating Uniform Quality



Indicating Non-Uniform Production



Indicating Trend Toward Oversize

head driven by a constant-torque device is linked to recording pen (ratio 150:1, hence 0.15" for each 0.001" deviation). Force to drive instrument mechanism is applied by lever which may be hand- or foot-operated. Operator needs no special training. Range 0 to 1.000"; chart range +0.003" to −0.003"; chart length 960" corresponding to 35,000 measurements. Dimensions 10½" × 5" × 6"; weight 7 lbs.—*Federal Products Corp., 1144 Eddy St., Providence 1, R. I.*

Please mention number 520 when filling out card

Vernier Caliper

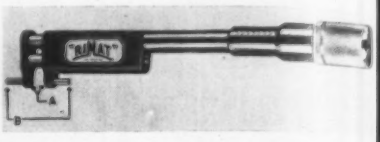
New "Rustless Chrome Vernier Caliper" (made in Switzerland) enables instrument mechanic to measure up to 6" in 0.0001" and 1/64" for outside, inside and depth dimensions; is provided with knife edges for measuring thread root diameter and with points for accurate dividing. Sliding action is extremely smooth when vernier is moved along scale. Blade and jaws are hardened throughout. Blade of an ordinary vernier caliper soon develops wear, but new caliper's slide is rustless chrome of such hardness, in comparison with bar, that wear between the two members is virtually negligible. Material is thoroughly normalized to eliminate possibility of change in size over the course of time. Jaws have an optically lapped finish and surfaces are accurate to eight millionths of an inch. In addition to English model, there is

available a model graduated in both English and Metric systems with vernier reading to 0.001" and 1/2 mm.—*George Scherr Co., 200 Lafayette St., New York 12, N. Y.*

Please mention number 521 when filling out card

Inside-work Micrometer

New "Model L" Longitudinal Duplex Micrometer is designed principally for inside work—to take both inside and

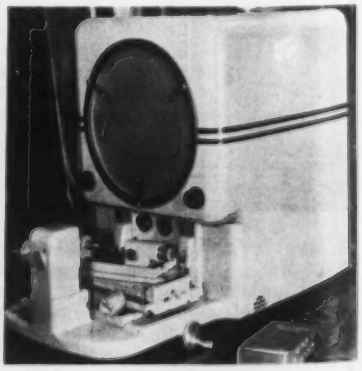


outside measurements of grooves and flanges on inside of bores. It is sufficiently small to reach into a hole as small as ½". Dimensions can be read while instrument is held in place. External measurements between points "A" and internal measurements between points "B." Measuring pins are hardened and ground on a radius. All wearing surfaces are hardened and ground, and are readily adjustable should it ever become necessary. Stainless steel is used in bright parts. Special sizes available.—*Richards Machine Tool Co., 124 S. Isabel St., Glendale 5, Calif.*

Please mention number 522 when filling out card

Contour Projector

New contour projector, originally designed for use in maker's own manufacturing operations, is said to embody "a number of optical principles never before incorporated in an instrument of this type." Four primary design objectives embodied in new instrument are: (1) adequate staging space between part and first lens, even at highest magnifications; (2) freedom from distortion at all points on viewing screen; (3) uniform, brilliant illumination, permitting use of instrument in fully lighted rooms without hoods or curtains; (4) ease of operation by eliminating need to refocus or make other adjustments when magnification is changed. Optical unit provides screen brightness approx. ten times greater than that of conventional comparators. (To reduce operator eye fatigue when instrument is in constant use, a rheostat is provided to diminish light intensity at will.) For measuring surface features or cavities, etc., where profile is obstructed, two powerful auxiliary surface illuminators behind heat-absorbing windows provide a



Now GERMANIUM VARISTORS

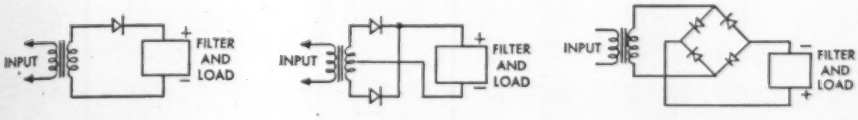
(CRYSTAL RECTIFIERS) by Western Electric

Western Electric announces a new line of Germanium Crystals! There are five types—all exceptionally compact and sturdy . . . all identical in mechanical dimensions . . . and all supplied with pigtails for soldering into circuits. Electrical characteristics have been standardized to meet the requirements of currently known applications.

—QUALITY COUNTS—

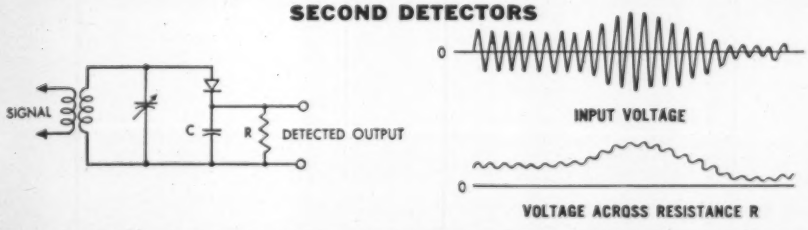
FOR THESE (and many other) APPLICATIONS

RECTIFIERS



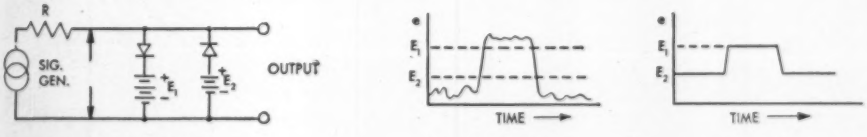
May be used as power rectifiers at peak inverse voltages up to 115, and peak forward currents up to 125 ma. By connecting matched units in series or parallel, these values may be increased.

SECOND DETECTORS



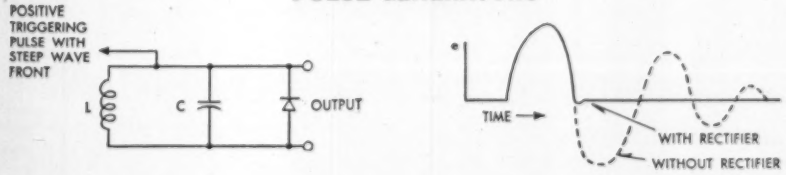
Used to good advantage as second detectors at frequencies to over 60 mc. They have much lower impedance than vacuum tube diodes, and are particularly effective in low-impedance circuits. The 1N47 is tested for operation at 100 mc.

SLICERS, LIMITERS AND CLIPPERS



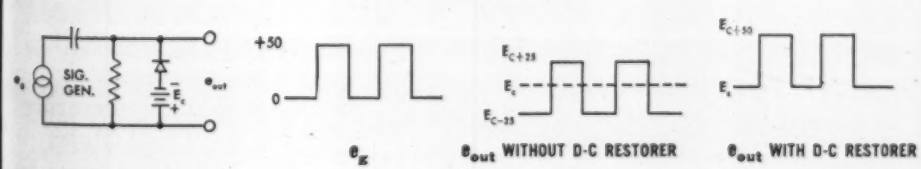
In the slicer circuit, biased units conduct current through R when critical voltages E_1 and E_2 are reached, preventing overswing. In limiters and clippers only one branch need be used, with addition of low-impedance d-c return path across output terminals or through signal generator.

PULSE GENERATORS



Unit damps out the oscillation after one-half cycle, producing a single pulse shaped similarly to half of a sine wave. This pulse may be clipped, provided clipper is isolated from pulse-producing tuned circuit to prevent damping out desired half cycle.

D-C RESTORERS



Circuit shows d-c restorer applied to a network widely used for coupling successive amplifier stages. The germanium crystal prevents output voltage from swinging below E_C; thus negative peak of wave is established at E_C.

For complete specifications and application data sheets on Western Electric Germanium Crystals, call your local Graybar Broadcast Representative, or write Graybar Electric Company, 420 Lexington Avenue, New York 17, N. Y.

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PORTABLE OSCILLOGRAPH

A portable oscillograph for laboratory or field use; this instrument incorporates high standards of accuracy with rugged dependability.

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Paper widths from 35 mm to 6 inches and a wide range of synchronous motor and tuning fork components are available for operation from 110 volts in the laboratory or for 12-24 volts d.c. truck or aircraft operation. Completely portable daylight developing equipment obtainable if required.

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bright image in natural color on screen instead of a shadow image. Both a surface image and a profile image can be projected at the same time. All lenses and mirrors have been ultra-hard coated by Kodak Lumenizing Process to reduce light loss and increase contrast. Cabinet is dust-tight, and a forced-air cooling system exhausts heat away from work area and operator.—*Eastman Kodak Co., Rochester 4, N. Y.*

Please mention number 523 when filling out card

Combination Surface-finish Comparator and Microscope

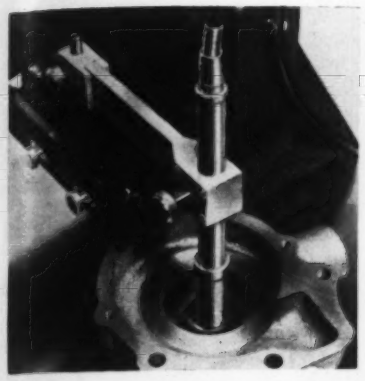
New "Comparoscope" is a dual microscope equipped with a master stage and a base with an adjustable stage. It can be used as a shop microscope (30×) but its outstanding feature is that its optical portion can be lifted from its base

and used on the job to evaluate surface finishes. Optical portion has a 6-volt "point-light" source (a transformer comes with outfit) and other essentials of a divided-field reflectoscope automatically focused on both "master specimen" and workpiece. Shop personnel without special training can determine surface-roughness values to approx. one millionth of an inch rms.—*The Comparo-Instrument Co., 16179 Hamilton Ave., Detroit 3, Mich.*

Please mention number 524 when filling out card

Surface-roughness-measuring Tracer for Blind Holes

New "Type GA" tracer (new accessory to "Profilometer") is for taking surface roughness measurements on bottoms of blind holes and on recessed flats and shoulders. It will measure in holes as small as 1" diameter, and can be used at any depth to 5½". Diamond tracing point projects from bottom of

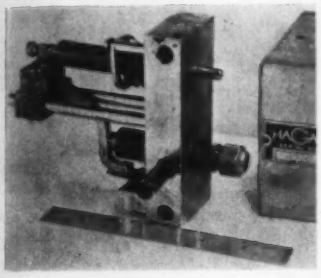


tracer at edge, and is self-adjusting to surface being measured. It can be used with any "Profilometer" and is mechanically operated by means of a "Type A Piloting Fixture." Tracer point has a vertical adjustment of 0" to 5⅞" above base plate of "Piloting Fixture," and a 1/16" and 1⅛" range of trace is provided.—*Physicists Research Co., 321 South Main St., Ann Arbor, Michigan.*

Please mention number 525 when filling out card

Pneumatic Motion Transmitter

New "Microtrans" converts translational motions over a range of 0 to 0.250" into pneumatic pressures of 5 to 30 lbs./in.^{2} which can be indicated or recorded on remote instruments. Test



application (recording expansion of turbine rotors relative to turbine casing) has been entirely successful. Output is linear; accuracy is better than 2%; stability is close to perfection; absence of ambient-temperature error and of vibration error suggests numerous applications where electric-gaging systems could not be used. Basic principle is force-balance and master measuring element is a selected "Iso-Elastic" spring. New transmitter is in effect a pneumatic micrometer with a measuring range of a quarter-inch instead of the usual few-thousandths indicating range of a production inspector's air-gaging instrument.—*Hagan Corp., Hagan Bldg., Pittsburgh 30, Pa.*

Please mention number 526 when filling out card

Electrical Motion Transmitter and Receiver

New "Type 156 Electric Micrometer" can perform usual gaging operations and is suitable for remote indication of small movements. It is battery-operated and consists of a transmitter, control unit and connecting cable. Transmitter is a sealed unit having a projecting plunger which will accept motions of ±0.010" from center

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NEW INSTRUMENTS • NEW TECHNICAL DATA

BULLETIN 100—"Resistance Standards and Resistance Bridges"

Included are complete descriptions of Rubicon Standard Resistors (Bureau of Standards and Reichsanstalt Types), Standard Shunts, Decade Resistance Boxes, Unmounted Decade Resistors, Wheatstone Bridges (laboratory and portable), Mueller Resistance Thermometer Bridge, Kelvin Bridges (laboratory and portable), and Limit Bridges (for production testing).

BULLETIN 270 — "Potentiometers"

Concise, factual information on Rubicon Type B High Precision Potentiometer, Type C Microvolt Potentiometers (single and double), Type D Microvolt Potentiometers, Portable Precision Potentiometers, Type S Students' Potentiometer, Temperature-Calibrated Potentiometers, Brooks Model 7 Deflection Potentiometer, and accessories including volt boxes, standard cells, keys and batteries.

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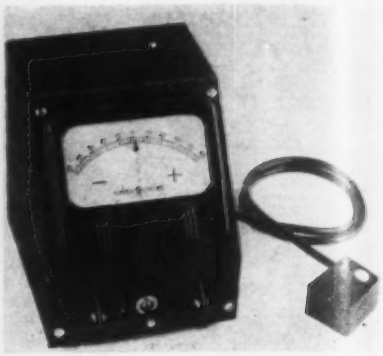
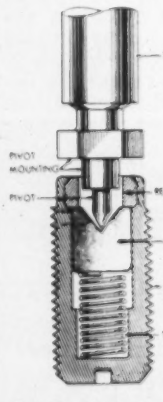


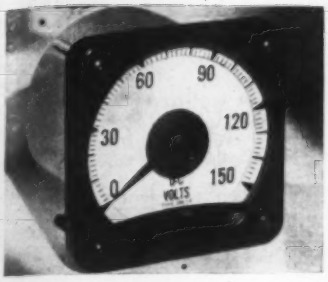
or 0.020" total in one direction. Control unit has a special zero-center indicating instrument which can be read to 0.00025" on a 4" scale. Equipment is said to be suitable for long life without maintenance. There are no tubes or amplifiers. Controls are minimized: one adjustment on transmitter, and two on control unit. Instrument may be purchased by some users for telemetering; by others for gaging and measuring in conjunction with suitable adjustable fixtures (not furnished by maker since every shop has stands, etc., for its purposes). Plunger contact pressures of 3½ oz. to 10 oz. are available by means of a thumb-screw adjustment. A standard hardened steel tip is furnshed; user may substitute a jeweled or any other desired tip. Transmitter size: 1½" × 2 1/16" × 1½" high; weight: 8 oz.; materials: noncorrosive; mounting: 4 holes tapped 6/32". Control Unit size: 5" × 6" × 7" high; weight: 3 lbs.—*Stevens-Arnold Inc., 22 Elkins St., South Boston 27, Mass.*

Please mention number 527 when filling out card

Long-scale Electrical Instruments

New "Type AB-15" (a-c.) and "Type DB-15" (d-c.) long-scale switchboard instruments employ bearings with spring-mounted jewels are designed for general switchboard use by electric utilities and large industries; have 250° scales 7.1" long, with numbered major divisions accented. All legends, such as "A-c. Amperes," etc., are located below center of scale: never partly covered by pointer. New bearing construction permits hard use without harm to pivots. If, owing to shock, pressure of pivot on jewel is appreciably higher than normal, jewel merely recedes into screw. Before jewel hits bottom, shoulder on end of shaft strikes top of jewel screw and takes the shock, thus protecting the jewel and pivot. Instruments can be easily disassembled for inspection or repair. Moving elements can be withdrawn from mechanism without disturbing control springs or jeweling. Thus, assemblies can be removed and replaced without noticeable change in scale distribution, often obviating need for re-



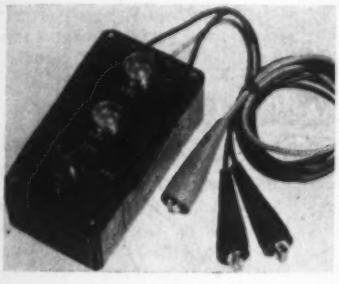


calibration and repair. Mounting dimensions and general case size have not been changed. "Types AB-15" and "DB-15" are mechanically interchangeable with older "Types AB-13" and "DB-13." Designed to meet requirements of Navy specifications, new long-scale line retains many features of maker's switchboard instruments: 1% of full-scale accuracy, anti-parallax scale, non-glare glass, thorough shielding from stray fields, external zero adjusters (when required), high overload characteristics, and good performance under varying ambient temperature.—*Meter & Instrument Div., General Electric Co., 40 Federal St., West Lynn 3, Mass.*

Please mention number 528 when filling out card

Phase Sequence Indicator

New "Model 40" phase sequence indicator is of simple operation: leads are connected and switch turned to proper

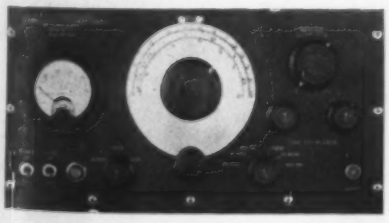


voltage. If rotation is CBA, lower light will glow; if ABC, top light will glow. Instrument utilizes principle that a capacitance connected in a three-phase circuit will cause current to lag voltage by 90°; can be used with 115-, 200-, and 440-volt circuits; weighs less than 1 lb.; measures 2" × 3" × 5½".—*Associated Research, Inc., 231 S. Green St., Chicago 7, Ill.*

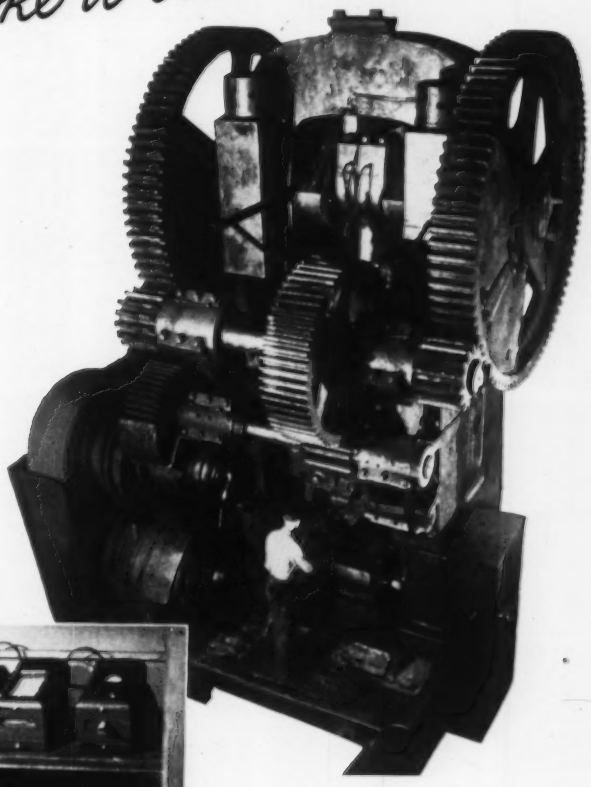
Please mention number 529 when filling out card

R-f. Oscillator

New "Type 410-A R. F. Oscillator" is designed for use as a general-purpose laboratory instrument and as a signal source for r-f. bridges. It is provided with an output voltmeter, a continuously adjustable output level control and an output level switch which makes it possible to obtain minimum distortion



Every time the crankshaft broke it cost $15,000...



Two Brush Double-Channel Oscillographs check the load at each corner of this huge forming press. Chart record is *instantaneous*.

Now Brush Direct-Inking Oscillographs Chart Each Strain!

At one of Cleveland's great steel plants, a problem needed solution . . . fast! When the strain was too much, the crankshaft of this forming press snapped—costing the company about $15,000 each time. To analyze the strain of this giant 3 million pound press, Brush Direct-Inking Oscillographs were installed. Now every strain draws its own record on Brush graph paper *instantaneously*.

Instantaneous, permanent, ink-on-paper recordings by Brush Oscillographs make their use almost unlimited. Accurate recordings of strains, pressures and countless electrical phenomena can be made over a frequency range of D.C. to 100 c.p.s. Either A.C. or D.C. signals can be measured. Whenever desired, recordings may be stopped for notations on chart-paper.

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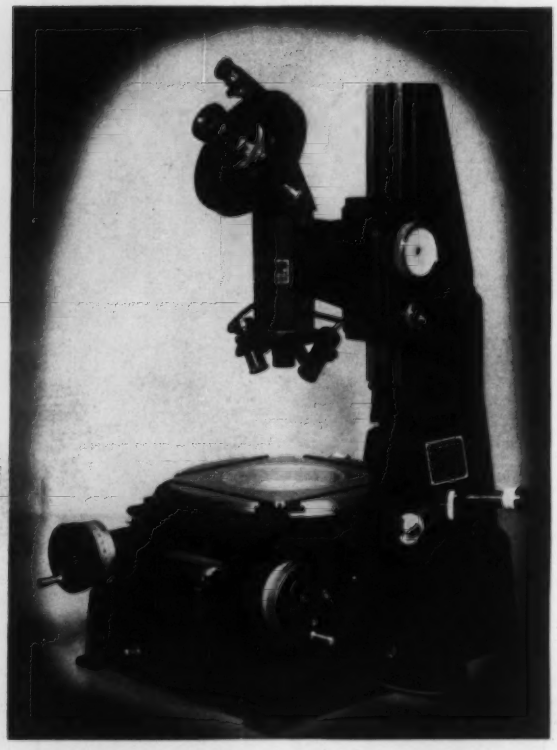

Especially useful for checking gear tooth spacings, laying out cam contours, and in performing numerous other precision measurements in either rectangular or polar coordinates.

Stage Rotation	360°
Direct reading to	1 minute
Coordinate Range	4 x 2 inches
Direct reading to	0.0001 inch

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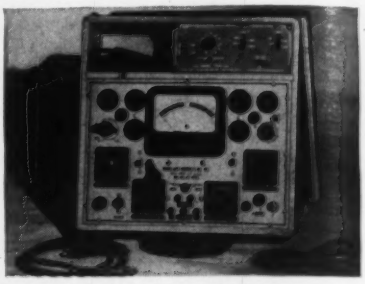
at normal levels, higher output voltage when a small amount of distortion is tolerable, and a modulated output for signal identification purposes. Circuit features a stabilized oscillator, a tuned buffer and a low-impedance power amplifier.—*Technology Instrument Corp., 1058 Main Street, Waltham, Mass.*

Please mention number 530 when filling out card

Combination Tester, Oscillator, Signal Generator, etc.

New "Model 8073 Servishop" is described as a "first-time-in-history . . . complete portable service shop." It is

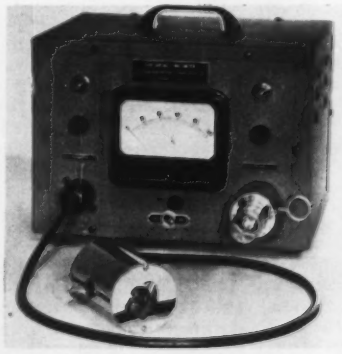


the equivalent of six essential instruments: tube tester, multitester, FM signal generator, AM signal generator, audio oscillator, and capacitor tester. Carrying case is 5" × 13" × 9½"; weight 15½ lbs. with all tubes, test leads and instructions, ready to operate on 50 to 60 cycles lines, 105 to 135 volts. —*Radio City Products Co. Inc., 152 W. 25th St., New York 1, N. Y.*

Please mention number 531 when filling out card

VHF-UHF Milliwattmeter

New "Type MW55 VHF-UHF Milliwattmeter" provides ready means for measuring power outputs of high-frequency transmitters, oscillators, etc. Two methods of measurement are provided, selection by a front panel switch. One is a thermistor bridge arrangement for indicating powers from



2 to 60 milliwatts; the other a PM filament brilliance comparison method for higher powers from 20 to 1000 milliwatts. Accessory probes, providing various methods of circuit coupling, plug directly into front panel or may be used remotely. Ambient-temperature compensation is incorporated. Unit operates from a 105-130-volt 60-cycle line and consumes approx. 40 watts. Dimensions 11" × 8" × 8".—*Rowe Radio Research Lab. Co., 2422 N. Pulaski Road, Chicago 39, Ill.*

Please mention number 532 when filling out card

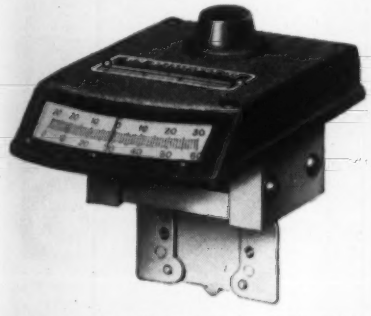
Conductivity Bridge for Ammonia Solutions

New "Model RD-23 Solu Bridge" is a modified a-c. Wheatstone bridge using an "eye tube" as null indicator; is direct-reading, covers range ½% to 5% NH_3. Manual temperature compensator range 15-35°C.—*Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J.*

Please mention number 533 when filling out card

Pointer Galvanometers

New '570-600 Series" Pointer Galvanometers feature exceptional current sensitivity through use of Alnico mag-

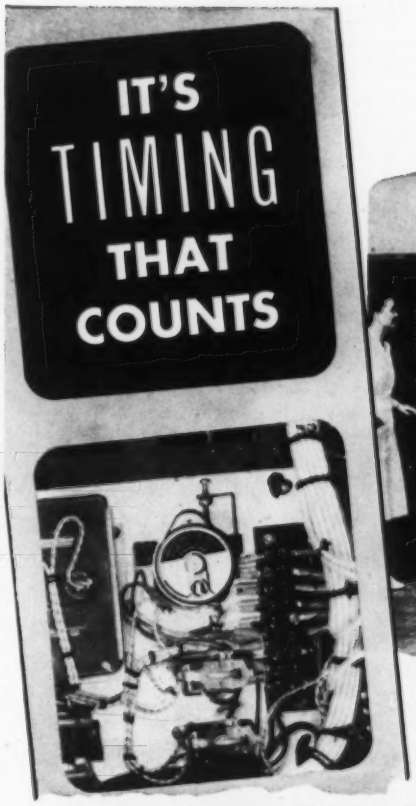


nets and are of rugged construction, making them suited to industrial apparatus, null point indicating in bridge and potentiometer circuits, etc. They require horizontal space 3⅜" × 5⅛" and extend 1-7/16" above and 2¾" below mounting surface; can be mounted conveniently on any horizontal panel and are fastened by 4 screws. No accurate leveling is required. They may be furnished with zero adjusted either left or center. Scale length: 60 mm.; period: 6 seconds; movement resistance: 100 ohms; sensitivity: 0.2 ma./mm.; ext. crit. damping resistance: 400 ohms. —*G-M Laboratories, Inc., 4300 N. Knox Ave., Chicago 41, Ill.*

Please mention number 534 when filling out card

3-sec.-period Galvanometers

New "Type E" galvanometer differs from conventional designs in that it has its moving system, magnet, lamp, scale and lamp transformer in a single, compact case. User simply places instrument on a bench or table, plugs into a 115-volt 60- or 50-cycle outlet. Sensitivity is ample for many potentiometer and bridge circuits: available sensitivities are 0.5 microvolt, 0.005 and 0.0005 microampere per mm. In addition, this instrument has, in effect, an added low sensitivity: if a deflection shoots light-spot off scale, a secondary spot appears. Moving only one-tenth as far as main spot, this secondary spot shows direction of deflection and approximate magnitude of circuit-balancing adjustments. Scale has 50 1-mm. divisions on either



IN WESTINGHOUSE
TUBERCULOSIS CONTROL

Tuberculosis detected in time can be cured . . . Westinghouse Electric's new portable, high speed X-ray unit is designed for mass chest examinations — 360 pictures an hour. A picture every ten seconds requires accurate timing — and at the heart of the PFX unit is a Haydon timer — a precision device for retarding the X-ray exposure until the rotating anode in the tube attains proper operating speed — a factor in prolonging tube life . . . a factor in protecting human life with Westinghouse Electric's PFX equipment.

This and thousands of other Haydon timing applications — not only in the medical field, but throughout all industry — demonstrate the trend to Haydon for timing quality.

If your requirements include timing devices, ask for Haydon's Engineering Data Catalog, or request a personal demonstration by a Haydon representative. For immediate reference, see Haydon Catalog, Sweet's File.

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MANUFACTURING COMPANY, INC.
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SUBSIDIARY OF GENERAL TIME INSTRUMENTS CORPORATION

capacitance gas-gage system

LONG-SCALE LIGHT-WEIGHT

ANTIPARALLAX INDICATORS

Accurate fuel-quantity indications under all conditions are possible with this reliable General Electric capacitance gas-gage system. Check these advantages . . . no moving parts in tank units—low power consumption—little unmeasured fuel—accuracy 2% under standard conditions—radio shielded—empty- and full-scale adjustments—wide spacing between tank unit tubes—indications not affected by foaming or surging.

DEPENDABLE INDICATIONS

Even extreme changes in flight altitude and temperature scarcely affect the accuracy of the readings. Immediate indication is given in the event of power failure.

For complete information on this new fuel-indicating system contact your nearest G-E Sales Office or write for Bulletin GEA-4873. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

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RESISTANCE THERMOMETER BULBS

Wires sealed in Pyrex or quartz. Protected from corrosion, oxidation and vibration. Air spaces completely eliminated — high speed of response.

Ranges: up to 900°F and to 2200°F.

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Write for Temperature Standards for standardization of thermometers.

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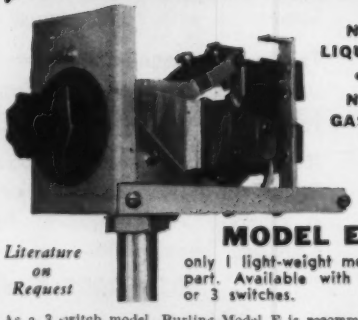

NO LIQUIDS • NO GASES

Literature on Request

MODEL E

only 1 light-weight moving part. Available with 1, 2 or 3 switches.

As a 3 switch model, Burling Model E is recommended for use (a) where load is divided into 3 parts, (b) where 1 switch is used for controlling, one as a high limit, one as a low limit, (c) to give definite stops on position to a 3 or 4 position diaphragm motor, (d) to give 3 speed control of variable speed motor.

Accurate, rugged, dependable. Corrosion and heat resisting tube. Dial pointer for easy setting. Locking screw locks temperature setting. Increased adjustable range to 700-1000°. Dimensions: 7¼" x 2¾" x 3½". Vapor tight base and cover with gasket available at slight extra charge.

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BURLING INSTRUMENT CO.

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Newark, N. J.

side of zero. Deflection is linear within 1%. Period is unusually short: about 3 seconds. If user requires several instruments of different characteristics, he needs only one complete galvanometer and additional moving systems: systems are easily interchanged and all use the same magnet.—*Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.*

Please mention number 535 when filling out card

A-c.-d-c. Power Supply

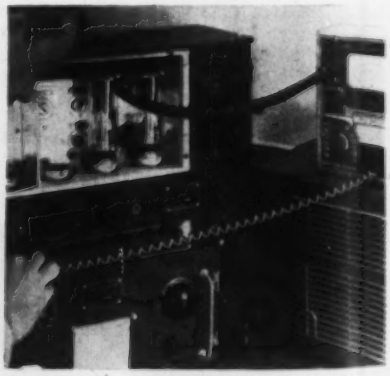
New "Bench Model 500-SV" combination a-c. and d-c. power-supply unit operates from 115-volt single-phase

50-60-cycle input; provides two independent output circuits, separately controlled and electrically isolated, for testing double-coil instruments, etc. Among features: vernier control on one output circuit enabling user to obtain hairline settings when checking specific points of instruments being calibrated. Both output circuits are uniformly adjustable from zero to maximum rating. Circuit No. 1 output: 0 to 10 amperes with a maximum of 8 volts, or 0 to 30/75/150/300/600/750 volts a.c. with a maximum of 200 ma.; also 0 to 20/50/125/250/500/750 volts d.c. with a maximum of 175 ma. Ripple on d-c. output <0.25%. Circuit no. 2: a-c. output 0 to 10 amperes with a maximum of 10 volts, or 0 to 135 volts with a maximum of 3 amperes, includes 115-volt constant-potential terminals supplied direct from input circuit; also d-c. output of 0 to 10 amperes with a maximum of 3 volts. Ripple on d-c. output <5%.—*Arthur E. Booth Co., 307 East Third Street, Los Angeles 13, Calif.*

Please mention number 536 when filling out card

Extensible Leads for Electrical Instruments

New "Koiled Kord Retractile Test Leads" are made in 48" retracted lengths which will extend to twenty feet. Each 48" retracted coil may be



cut into any desired length; ratio 1:5. "Koiled Kord" leads come in conventional red and black. Any type of test lead terminals may be applied.—*Koiled Kords, Inc., Box K, Hamden, Conn.*

Please mention number 537 when filling out card

Television Test Generator

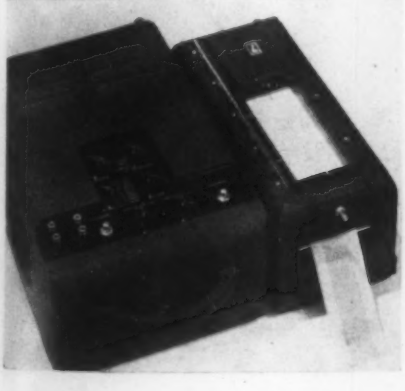
New "Type WA-3A" Grating Generator, first commercial instrument of its type, provides a means for determining correct linearity alignment of deflection circuits for television receiver picture tubes and television camera pick-up tubes. It produces on picture tube a pattern consisting of crossed horizontal and vertical bars, similar to a lat-

tice or a grating. Horizontal bars are used for checking vertical alignment; vertical bars for checking horizontal alignment. Equal spacing between bars indicates perfect linearity. Crowding or spreading of bars signifies improper alignment. Curvature of bars reveals effect of stray magnetic fields. By observing grating pattern on a kinescope, it is possible to adjust scanning velocity to produce uniform distribution of picture detail. Even small degrees of non-linearity may be detected, permitting adjustments for clear reproduction of fine details.—*Test & Measuring Instrument Section, RCA Victor Division, Radio Corp. of America, Camden, N. J.*

Please mention number 538 when filling out card

Strain Amplifier

New "Model BL-310 Strain Amplifier" is designed for use with maker's direct-inking oscillograph as illustrated. This combination, known as "Direct Recording Strain Analyzer" (trademark), permits immediate chart records to be made with either Baldwin "SR-4" bonded-wire strain-gage units or with Statham Lab. unbonded-wire units—or with many other types of pick-ups. New amplifier contains two arms of Wheatstone bridge; user connects third and fourth arms externally, one as active gage, the other for sensitivity doubling or for temperature compensation. Resistance and phase-balanc-



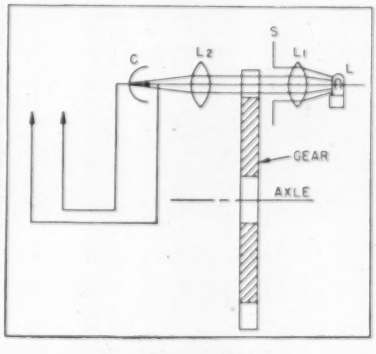
INSPECTION OF MOVING GEARS IS EASY with a DU MONT OSCILLOGRAPH

(A) A perfect gear

(B) An eccentric shaft

(C) Irregularity of tooth size or angular spacing

★Irregularity of toothshape and any eccentricity of a gear, *in motion*, is easily detected with the new methods of Du Mont Oscillography. Consider this simple test setup for examining a gear for regularity of tooth and concentricity of rotation:



Simple test setup

L is a source of light; L_1 is a lens; S is a narrow slit. Light is projected onto the gear as the gear rotates, the teeth varying the intensity of the beam in its passage to lens L_2, and photocell C. C is connected to the vertical amplifier of a cathode-ray oscillograph, such as the Du Mont Type 247 (illustrated). The sweep of the oscillograph occurs each time a tooth passes by.

If the gear teeth are uniform and if the gear runs concentrically, these facts will be shown on the oscillograph by a curve which looks like Fig. A—a uniform and stable curve.

If the shaft is eccentric, the curve will appear as in Fig. B; or if the gear teeth are not uniform, the curve will look like Fig. C.

Thus the characteristics of the gear in the machine may be examined easily and inexpensively under dynamic conditions through the new methods of Du Mont Oscillography.

★ The foregoing is but one of many applications of Du Mont oscillographs to the varied problems of mechanical engineering. Why not inquire now into the possibilities of applying a Du Mont oscillograph to your mechanical problem?

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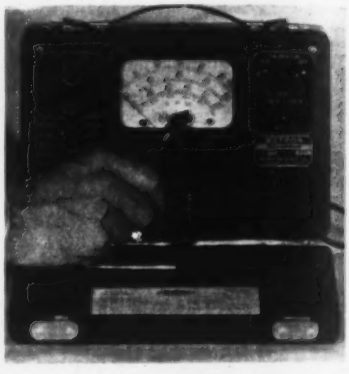
WANTED: Man to take charge of development and design department of instrument company manufacturing a wide diversity of testing instruments and scientific apparatus. Leadership and experience important. Write giving complete background as to education and experience, age, salary expected. Location—Middle Atlantic States. All correspondence confidential. Box 149, Instruments Publishing Company, 1117 Wolfendale Street, Pittsburgh 12, Pa.

ing controls are located on panel and provision is made for connecting an internal calibration resistor in bridge circuit and adjusting over-all gain. New amplifier may also be adapted for use with direct-writing recorders of other makes (Esterline-Angus Co., etc.). Recommended gage resistance: 120 ohms; bridge energizing frequency: 2000 cps.; power required: 135 watts (on 100-125-volt 60-cycle source); weight: 30 lbs.—*The Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio.*

Please mention number 539 when filling out card

¼%-accuracy Tachometer

New "Precision Tachometer" is accurate to ¼% of speed being measured; is available as "Type 48H," 900 to 10,-

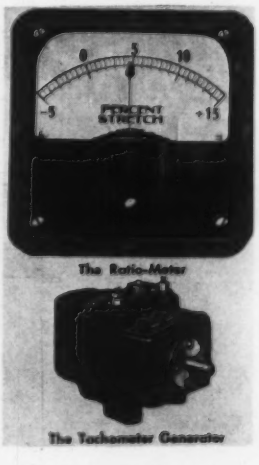


000 rpm; and "Type 48J," 90 to 1000 rpm. Each has ten overlapping ranges, selected by a rotary switch. No damage results from accidental selection of wrong range. Self-calibrating feature: speed measuring circuit matched against internal precision resistors, thus insuring readings against changing ambient conditions.—*Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.*

Please mention number 540 when filling out card

Speed-ratio Tachometer

New "Speed-Ratio Tachometer," designed to provide more accurate control in processes wherein materials are subject to change due to differences in rate of travel, includes a special speed-ratio indicating instrument which operates in conjunction with two small d-c. generators to convert mechanical rotation

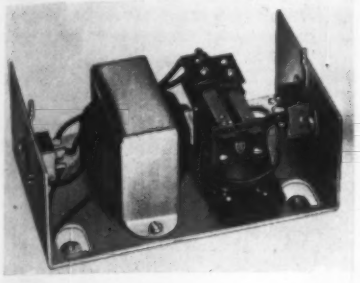


into measurable electrical magnitudes. The generators are connected to input and output drives of machine, and wired to ratio indicator which is calibrated as desired (% stretch, % shrinkage, % elongation, etc.). Indicator can be mounted for easy reading by operator; and, where required, an additional indicator can be wired into circuit for use at a distance. Also, one or more indicators calibrated in production terms, such as "Yards per Minute," may be connected to output tachometer generator.—*Weston Electrical Instrument Corporation, 617 Frelinghuysen Avenue, Newark 5, N. J.*

Please mention number 541 when filling out card

Liquid Level Controller

New "Series G-53143" Liquid Level Control designed principally for refrigerated storage tanks, is of electrical

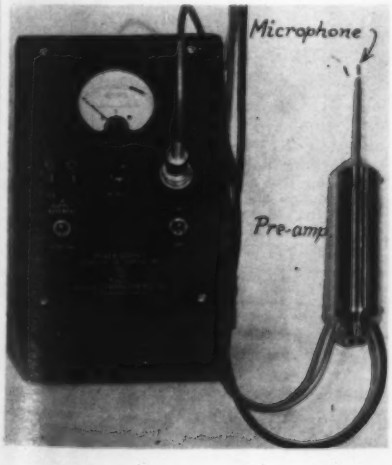


type: a long and a short electrode are inserted through top of tank; when liquid drops below level of long electrode, relay releases, closing pump motor circuit; when level rises to short electrode, relay closes, stopping pump motor, which does not operate again until level drops below long electrode. A transformer is used to reduce current required by relay, and also to isolate electrode circuits from power line.—*Dept. LL., Guardian Electric Mfg. Co., 1638 W. Walnut St., Chicago 12, Ill.*

Please mention number 542 when filling out card

Sound Pressure Measurement System for Audible & Ultrasonic

New "Model GA-1005 Sound Pressure Measurement System" permits convenient and precise measurements of absolute sound pressure over frequency range 50 cycles to 250 kc. It includes new wide-range "Model M-113" standard microphone, shock-mounted



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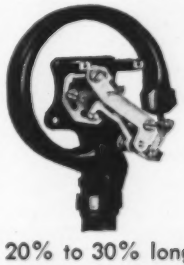

20% to 30% Longer *Bourdon* Tubes

Bourdon tubes in the ACRAGAGE are 20% to 30% longer than average . . . resulting in the following advantages: less strain per unit length on the spring; increased durability; longer fatigue life; heavier wall thickness for added safety; greater tip-travel — providing sustained accuracies to within one-half of one percent!

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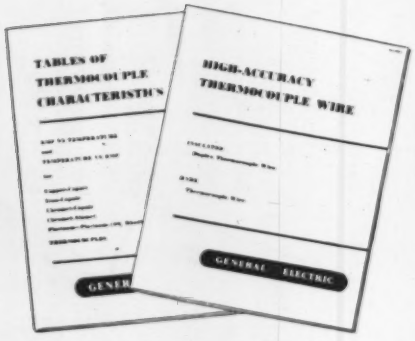


Because temperature is one of the most important quantities measured in industry today . . . and because thermocouples provide the most convenient method of measuring temperature . . . these two publications should be of interest to you.

1. **"TABLES OF THERMOCOUPLE CHARACTERISTICS"** (GET-1415) gives the emf vs temperature characteristics of common thermocouple materials. These tables are the result of considerable engineering experience and research by the General Electric Company. Great care has been taken to make them as complete and as accurate as possible, yet convenient to use.

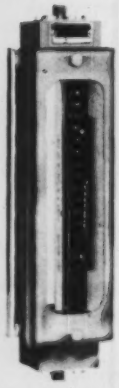
2. **"HIGH-ACCURACY THERMOCOUPLE WIRE"** (GEA-4881) gives information on applications, selection, accuracy, and prices of various types available from General Electric. This should be helpful to you in selecting the proper materials for your temperature measurement applications. In addition, General Electric has excellent facilities for meeting special requirements in both insulated wire and completed thermocouples.

Get your copies of these valuable booklets by writing today for GET-1415 and GEA-4881. *Apparatus Department, General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC

602-120

The Full-View ROTAMETER

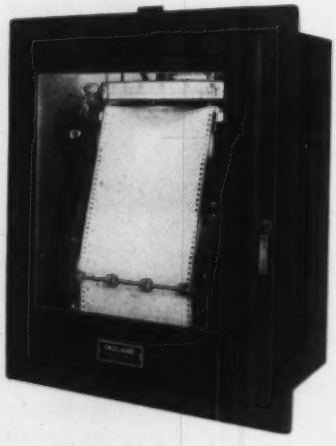


Precision-die precision

The Full-View Rotameter is assembled just like a precision die. The frame fits together precisely with 8 stainless steel dowel pins. This construction gives speed and simplicity in assembly, freedom from strain on the pyrex metering tube and additional rigidity to withstand piping stress—all of which contributes to lower instrument maintenance. For full information, write for Folder 20 to

BROOKS ROTAMETER CO.
BOX A-5548 LANSDALE, PA.

Engelhard Recorders



This is the new flush mounting case for the well known Engelhard Direct Deflection Indicator-Recorder. It was shown for the first time at the recent Chemical Show in New York and received wide approval.

It is now possible to use this instrument on panel type construction control boards, and be harmonious in looks with other necessary units.

The outside is finished in fine grain black wrinkle, and the interior is illuminated by means of a fluorescent light. Construction is reinforced steel.

Bulletin #800 for CO_2
Bulletin #400 for Pyrometry

CHARLES ENGELHARD, INC.
900 Passaic Ave. East Newark, N. J.

preamplifier with 25 ft. output cable and power supply unit complete with batteries. Diffraction errors are completely eliminated for all measurements throughout entire audible range to beyond 20 kc. because microphone diameter is only ⅛". Microphone acts as a pure mechanical stiffness up to 250 kc., assuring constant phase angle between generated voltage and actuating sound pressure up to 250 kc. and hence accurate reproduction of transients. Dynamic range from a few dynes/cm² to 10^6 dynes/cm² (194 db level) without distortion; a special fixture furnished with system simplifies exact absolute calibration.—*Massa Laboratories, Inc., 3868 Carnegie Avenue, Cleveland 15, Ohio.*

Please mention number 543 when filling out card

Glass Cutter

New glass cutter made of Kennametal which has an extremely hard and enduring cutting edge is recommended

in place of ordinary triangular file. It consists of a blade 3¼" long mounted in a hardwood handle.—*Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.*

Please mention number 544 when filling out card

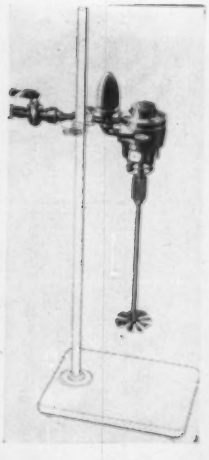
Draftsman's Adjustable Curve

New model of "Arcmeter" has a range of radii from 20" to infinity, between which limits a true arc can be

determined by direct reading on graduated scale. This is accomplished without need to establish a circle center. Adjustment is easily made by moving an indicator knob attached to a movable cam. Cam action, in turn, affects curvature of a specially-designed steel spring. Instrument is 16" long × 3⅛" wide and produces a 15" arc.—*Arcmeter Co., 2016 Sixth Street, Rockford, Illinois.*

Please mention number 545 when filling out card

Air-driven Stirrer



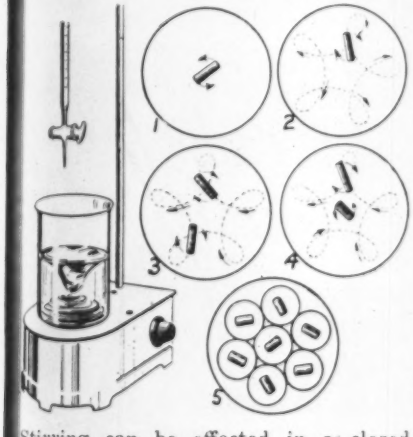
New "Mixaire" air-motor stirrer achieves variable speed from 0 to 6,000 r.p.m.; can replace electric motors in 0 to 1/6 hp. range; cannot explode under any conditions, does not generate sparks and "more than meets all safety requirements." It is recommended for pressures below 100 lbs. and speeds below 6,000 r.p.m. Speed is increased or decreased by adjusting valve on air supply. "Mixaire" will start from any position, and run at speeds as low as

100 r.p.m. without stalling. Its diameter is 2½" and its weight 3 lbs. End of shaft is equipped with grease-sealed ball bearings. Silent operation is assured by muffler. "Mixaire" is easily mounted as illustrated, on any standard laboratory support stand or clamp fastener; also to top or side plates of tanks or baths with plate thickness up to 3/16". It is supplied complete with pulley and chuck for shafts up to ¼" diameter, nickel-plated stirrer, 9" shaft, and 2" diameter propeller.—*Emil Greiner Co., 161 Sixth Ave., New York City.*

Please mention number 546 when filling out card

Magnetic Stirrer

New "Rosinger Magnetic Stirrer" performs functions previously either impossible or done with great difficulty. Principle of operation is to cause a magnetic bar, covered with a protective coating, to rotate in a liquid contained in a vessel of non-magnetic material. Motion of magnetic bar is effected by a rotating magnetic field, created by a permanent magnet kept in motion by a motor, both encased in a cast-aluminum housing together with a rheostat for controlling speed of motor and rate of stirring. Housing has a flat top of white plastic or duralumin. Liquid to be stirred is poured into vessel and placed on top of stirrer. Then stirrer is put into motion by dropping stirring element (or rotor) into liquid and switching on rheostat.

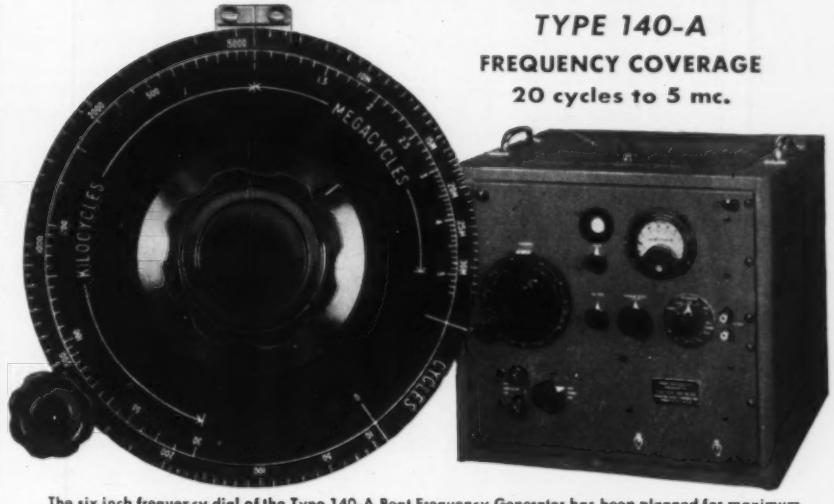


Stirring can be effected in a closed vessel, under any pressure, under vacuum, and under sterile conditions. Another advantage is that it is adaptable for small amounts of liquid in microchemical work, as well as for large volumes. The following effects of stirring are shown graphically:—(1) Using one stirring element. Effect: Central rotation, vortex formation. (2) Using one element. Effect: Epicyclic motion of the stirring element. No vortex formation. (3) Using two elements. Effect: Interlocking epicyclic motion of the stirring elements. Quick splashless stirring. (4) Using two elements. Effect: Central rotation of one element and epicyclic motion of the other. (5) Simultaneous stirring in several test tubes or small containers. Note: Effects 2, 3 and 4 can only be created in round-bottom vessels. Apparatus operates on 110-volt a.c., 60 cycles. It can be used as a laboratory stand, using ½" diameter 2-ft. long duralumin rod which is part of assembly. Using a regular laboratory stand with a ½"

BEAT FREQUENCY GENERATOR

TYPE 140-A

FREQUENCY COVERAGE
20 cycles to 5 mc.



The six inch frequency dial of the Type 140-A Beat Frequency Generator has been planned for maximum readability and rapid setting, with combined scale lengths of the low and high ranges exceeding 22 inches. Continuous coverage of the entire audio spectrum is possible without bothersome range switching.

Frequency Range: 20 cycles to 5 megacycles in two ranges. ***Low Range:*** 20 to 30,000 cycles. ***High Range:*** 30 kc to 5 megacycles. ***Frequency Calibration:*** Accuracy ±2 cycles up to 100 cycles, ±2% above 100 cycles. ***Adjustment:*** High and low ranges have individual zero beat adjustments. Low range may be checked against power line frequency with front panel 1 inch cathode ray tube. ***Output Power and Impedances:*** Rated power output: one watt, available over the low frequency range from output impedances of 20, 50, 200, 500, 1000 ohms, and over both ranges from an output impedance of 1000 ohms. ***Output Attenuator:*** Five steps: X1.0, X0.1, X.01, X.001, X.0001. Distortion: 5% or less at 1 watt output; 2% or less for ½ voltage output. ***Write for Catalog "D"***

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FOR
Precision Data Transmission

The only available Pressure Transducers combining high accuracy with large electrical outputs proportional to gage, absolute, or differential pressures. (Instrument shown is for differential fuel measurement — Type 4517). These instruments consist of a bellows, a connecting linkage, a Microtorque Potentiometer. All components are housed in a compact, rugged unit. Many ranges of pressures and resistances . . . standard resistance is 5,000 ohms. Where space is at a premium, write for details of the Type 4513 Pressure Transducer.

Write for engineering details.

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Relays
Delayed
"Make" or "Break"
Automatic
Circuit Control
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(Choice of 7 scale ranges)

A precision built instrument adaptable to most industries where heat indication is a factor.

This instrument may also be used as a standard to check other instruments throughout your plant. It is built into a walnut carrying case with a leather handle.

We also have a full line of thermocouples for all uses, as well as many other models of indicating instruments, both wall and portable.

Write for Bulletin 40-HR. Reps. wanted.

ELEMATIC EQUIPMENT CORPORATION
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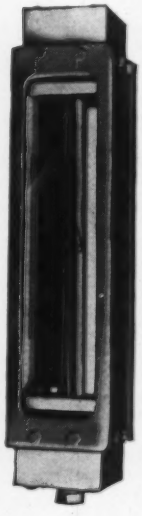
diameter rod, stirrer itself can be raised or lowered to any desired position. Stirring elements made from Alnico 5 permanent magnets, are supplied in various sizes; gold-plated for protection against chemical reagents; encased in rubber or plastics, when needed, to eliminate noise, protect containers, etc.—*Ivan Sorvall, Inc., 220 Fifth Ave., New York 10, N. Y.*

Please mention number 547 when filling out card

All-stainless-steel Rotameter

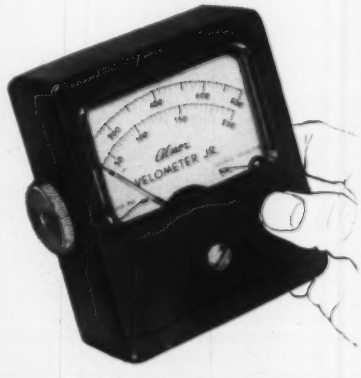


New Special Full-View Rotameter with Safety Shielding for corrosive services is said to be unique in that ordinarily a meter of this type has internal metal parts (in contact with fluid) made of stainless steel or other special metals, whereas new meter has all external metal parts also made of stainless steel. These parts include side plates, window frames, gland followers, cap screws and gland bolts. New meter therefore withstands external corrosive action as well as internal corrosion. It is made with screwed connections in sizes ¼" to 1½" and with flanged connections in sizes 1" to 3". It will measure flow rates as high as 120 gpm. of liquid or 240 cfm. of gas.—*Brooks Rotameter Company, Box B-5248, Lansdale, Pa.*

Please mention number 548 when filling out card

Air-velocity Indicator

New "Alnor Velometer Jr." gives instantaneous measurement of air velocities in unrestricted areas, does not require the use of jet attachments but is completely self-contained. It is 4" high, 3" wide, 1½" deep, weighs 8 ounces and has single or double velocity range scales. It is calibrated to provide direct reading of air velocity in either fpm. or mph. without timing, calculations or reference to tables and charts. Movement is double-pivoted, double-jeweled; air-actuated pointer vane and hairsprings are protected by molded Bakelite case. Instrument comes with a genuine leather, nylon-stitched carrying case with brass fittings.—*Illinois Testing Labs., Inc., 420 N. LaSalle St., Chicago 10, Ill.*



Please mention number 549 when filling out card

Stroboscopic-principle Flow-rate Indicator

New "Stroboflow" is said to permit measuring liquid flow-rates "with a degree of accuracy heretofore unobtainable." It comprises a precision-made turbine mounted on stainless steel pivots in Graphitar bearings between transparent panes. Rotational speed of turbine (proportional to flow) is determined from stroboscopic effect of light viewed through an aperture in the turbine disk. Instrument is calibrated in terms of stationary patterns of images. Once a predetermined pattern (desired flow rate) is established, any deviation from this rate of flow will cause pattern to precess. Direction of precession, clockwise or counter-clockwise, indicates decreased or increased flow-rate; amount of precession is a measure of loss or gain in amount of liquid delivered. Untrained observer can distinguish displacement of patterns by two degrees of arc which, on instrument's inherently expanded scale, corresponds to 0.04% at a flow of 1 gpm. This method is said to permit an operator to maintain a desired flow-rate for long periods without fatigue. Flow-rate pulsations are instantly apparent: a rhythmic pulsation merely causes a

corresponding oscillation of pattern about index position and cannot result in a false indication of average value. Pulsations of a type which result in excess displacement in one direction are shown by a continuous, if not uniform, precession in a corresponding direction: are easily recognized and easily compensated to average level. An outstanding feature of Stroboflow operation is that range is extended without impairment of accuracy by a simple change of jets (interchangeable in any "Stroboflow" without change in calibration). Five standard jets, supplied with each instrument and for which each instrument is calibrated, provide forty different flow-rates in one instrument. Since flow-rate, rotor speed and jet characteristic are all linearly related, it is practicable to adapt several "Stroboflows" to indicate different rates of flow while exhibiting identical patterns. "Stroboflow" is of simple construction: only one moving part; not easily damaged; self-cleaning; will tolerate small particles without losing accuracy. Electronic components are standard items conservatively applied. Maintenance costs nil. Energized from 117-volt single-phase 60-cycle source.—*K & K Engineering Co., Bolton, N. Y.*

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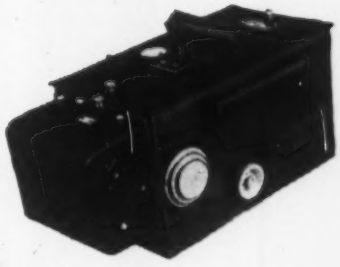

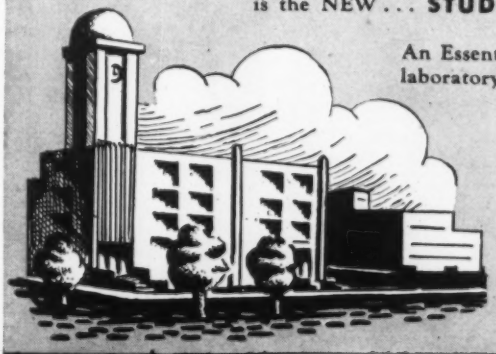

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- UNIVERSAL MOUNTING
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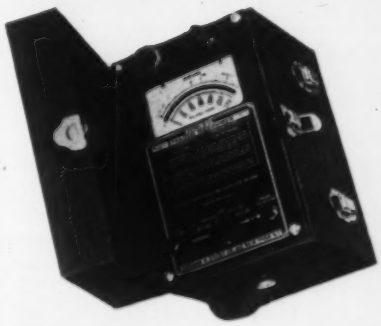

1. **Insulation Tester,** 0-200 megohms, 500 volts DC test potential. With exclusive triple-color grading scale.
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3. **AC Voltmeter,** 0-150/600 volts.
4. **DC Voltmeter,** 0-150/300 volts.

Full details in Bulletin 441

HERMAN H. STICHT CO., INC.
27 PARK PLACE NEW YORK 7, N. Y.

Instrument Craftsmanship Training Course

By G. A. LARSEN, The Texas Company, Lockport, Illinois

WITH increased use of instruments and the development of new processes requiring numerous complex control systems, we find it necessary to use only trained instrument mechanics. To meet this demand for trained personnel, we have developed a training program at our Lockport refinery that meets adequately our instrument training requirements at this plant. This training course has been used for the instruction of returned veterans and serves also as a refresher for the experienced or partly-trained members of the Instrument Department.

It is our feeling that other users of control equipment, not only in the petroleum industry but in others as well, would find some interest in our training method.

The course of study as outlined here includes a schedule to be followed by the instructors in providing basic data, as well as "on-the-job" experience with the various types of control devices used in refinery service.

The instructor using this outline will find it necessary to make certain revisions in this schedule to meet the specific needs of his plant or industry. The course of instruction is sufficiently flexible to be used in numerous industries other than an oil refinery.

Job training methods similar to those recommended by the War Manpower Commission for training within industry have proved quite satisfactory in this program.

Classroom instruction is under the direct supervision of the Instrument Department foreman, assistant foreman or other specially-trained job instructors. For "on-the-job" instruction or field work, the trainee is assigned to work with an experienced craftsman on the various operating units.

Candidates for training should be selected on a basis of aptitude, education, past experience and enthusiasm. The educational requirement for this craft should be at least four years of high school or its equivalent. The high-school course should have included physics and chemistry. This amount of formal education greatly reduces the amount of classroom instruction required as basic or related training.

The training program should be continuous and intensive, with a minimum number of interruptions in the schedule. Daily schedules should be maintained even though it may be found necessary to reduce the allotted time for training. We fully realize that this job instruction program will not produce master craftsmen in a few months, but the trainees will have received sufficient basic knowledge to enable them to carry on their duties in the field and improve their skill by actual experience on the equipment while in service.

Frequent questionnaires and work performance tests reveal the trainee's progress. Our numerous test and inspection periods on operating units provide excellent facilities for on-the-job training.

One hour is considered one training period in this schedule. The training time may be varied to meet plant requirements and the degree of skill required. The minimum numbers of training periods required for various subjects are tabulated and represent what we consider the minimum training time for each subject. The symbols for various types of instruction are as follows:

D—Discussion or lecture periods.
L—Laboratory demonstrations.
F—Field work "on-the-job" training.
V—Visual (movies or slides).

The trainees are required to maintain a complete notebook of key points and special data for future reference.

The Instrument Department library includes all instruction books and field manuals of the well-known instrument manufacturers. In addition to these we have as supporting data the texts and publications listed in Appendix A.

These books are available to the trainees or department members on a check-out system.

There is no specific recommendation for these books as against any others. They have been listed merely because they were found useful to us in our training program at the Lockport Refinery.

Other books and publications are added to this library as they come to our attention or become available.

A suitable lecture and demonstration room must be provided for conducting

TRAINING SCHEDULE

Estimate of required periods
250 hrs. D periods (Discussion and Lecture)
73 hrs. L periods (Laboratory Demonstrations)
28 hrs. V periods (Visual—Movies and Slides)
733 hrs. F periods (Field Work—Job Instruction)

SECTION I (BASIC)

Subject	*Training Period (hours)*	*References (See Appendix A)*
Departmental Organization	1D	—
Safety Methods and Practices	2D	1
Work as Chart Changer	30 hrs. minimum	—
Mathematics (as required)	—	Text selected by instructor
Physics	20D-10L	3, 4
Chemistry	10D-5L	3
Electricity and Magnetism	20D-10L-10V	3, 14
Electronics	20D-12L-12V	13, 15
Blueprint Reading	10D	—
The Texas Co. Instrument Specifications	5D-3V	2
The Texas Co. Meter Hook-up Standards	10D-3V	2
Instrument Shop Facilities and Testing Equipment	10D	10,
(a) Portable Test Potentiometers		10, 11, 17
(b) Thermocouple Checking		5, 11, 18
(c) Circuit Testing		10, 17
(d) Use of Ohmeter		10, 17
(e) Gage Testing and Calibration		10, 17
(f) Meter Testing and Calibration		10, 17
(g) Operation of Combustible Gas Indicators		10, 17
(h) Instructions for Gas Testing		1, 10, 17

SECTION II

PRESSURE INSTRUMENTS:		
1. Manometers (U-Gage and Well Type)	1D-1L-3F	6, 10, 11, 17
2. Draft Gages	1D-1L-10F	11, 17
(a) Limp Diaphragm Type		
(b) Inclined Manometers		
3. Bourdon-tube Gages	1D-1L-10F	11, 17
(a) Bronze Tube		
(b) Drawn Steel Tube		
4. Pressure Recorder Tubes	1D-3F	11, 17
(a) Helical		
(b) Spiral		
(c) Bellows		
5. Special Bourdon Type Gages	1D	10, 11, 17
(a) Suppressed-zero Gage		
(b) Retard Gage		
(c) Compound Gage		
6. Calibration Methods	2D-10F	10, 11, 17
(a) Dead-weight Tester		
(b) Laboratory Test Gages		
(c) Mercury or Water Manometer		
7. Linkage and Angularity	1D-1F	2, 11, 17
8. Protective Devices for Gages	1D-1F	2, 11
(a) Pulsation Damping		
(b) Syphons for Steam		
(c) Seals for Corrosive Materials		
9. Pressure-pen Settings	3D-5F	7, 8, 9, 10
(a) Gage Pressure		
(b) Absolute Pressure		
(c) Calculations for Square-root Charts		

Demonstration End of the Classroom, Instrument Department, Lockport (Illinois) Refinery of The Texas Company

the training course. A typical classroom, shown in the accompanying photograph, will accommodate a class of twelve and is equipped with all necessary training equipment. The instrument panel is equipped with various types of instruments, each connected to simulate some type of actual control. Listed below are the facilities furnished our instrument training department:

- 1—File cabinet for books and records.
- 1—Instrument panel equipped with air header and power outlets.
- 1—Orifice section 2" pipe with ½" orifice.
- 1—4' × 6' blackboard.
- 1—4' × 6' worktable.
- 12—Folding chairs.
- 1—30" U gauge.
- 1—30-lb. Hg-filled well-type manometer.
- 1—Slide projector.
- 1—Electronics Training Course (Visual—slide films and booklets.)
- 1—½" Control valve.
- 1—Valve positioner.
- 3—Transmitters and receivers, Types "A," "B" and "C."
- 2—Mercury-less transmitters, Types "A" and "B."
- 3—Pneumatic Controllers, Types "A," "B" and "C."
- 1—Self-balancing Temperature Recorder Type "A."
- 1—Electronic Temperature Recorder Type "B."
- 3—Level controllers, Types "A," "B" and "C."
- 3—Pressure gages, Types "A," "B" and "C."

[EDITOR'S NOTE.—The "types" are different makes; only the letters A, B and C are used in each line but there are more than three makes altogether.]

Upon entrance into the Instrument Department as trainees, the men are given an opportunity to acquaint themselves with the department personnel, location of operating units and shop methods and practices. After several days of orientation the trainees are assigned to the various chart routes. In this work, the men learn the plant

SECTION III

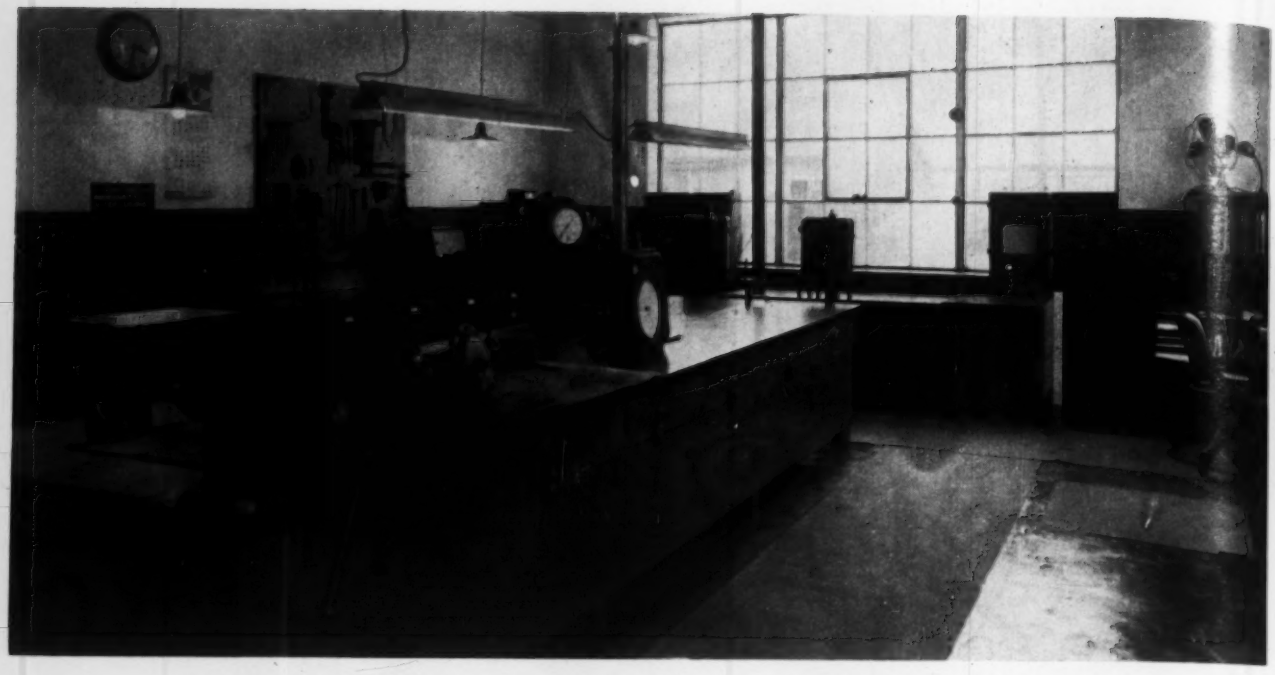
Subject	*Training Period (hours)*	*References (See Appendix A)*
CONTROL VALVES AND REGULATORS:		
1. Types and Services (a) V-Port (Single- and Double-seat) (b) Parabolic (Single- and Double-seat) (c) Globe Type (Quick-opening) (d) Butterfly Type	3D-36F	2, 10, 11, 17
2. Valve Motors (a) Diaphragm-and-spring (b) Diaphragm—Springless (Pressure-balanced or -loaded) (c) Liquid- or Air-operated Piston (d) Electric Motor Drive (e) Solenoid-operated	2D-5F	11, 17
3. Self-operated Regulators	1D	17
4. Pilot-operated Regulators	1D	17

SECTION IV

TEMPERATURE MEASUREMENT:		
1. Pressure-spring Thermometers (a) Liquid-filled (b) Vapor Tension (c) Gas-filled	2D-18F	10, 11, 17
2. The Thermocouple (a) Theory (b) Types ("A," "B" and "C") (c) Polarity Determination (d) Correct Method of Installation (e) Testing and Fault Finding	2D-1L-8F	11, 18, 17
3. Extension Lead Wire (a) Color Code (b) Installation Details	1D-1L-10F	10, 11, 17
4. Millivoltmeter Pyrometers (a) Theory (b) Care and Maintenance (c) Checking (d) Calibration (e) Cold-junction Correction	2D-2L-10F	11, 17
5. Potentiometers (a) Indicating (Types "A" and "B") (b) Recording—Mechanical (Types "A," "B" and "C") (c) Electronic (Types "A" and "B")	20D-80F	11, 17

SECTION V

FLOWMETERS:		
1. Differential (Orifice Type) (a) Principle of Operation (b) Orifice Section Requirements (c) Testing and Calibrating Methods (d) Routine Maintenance	6D-2L-60F	7, 8, 9, 10, 11
2. Displacement Type (Volumetric) (a) Principle of Operation (b) Checking and Calibrating (Types "A," "B," "C," "D" and "E")	6D-40F	10, 17



A Corner of the Repair Shop, Instrument Department, Lockport (Illinois) Refinery of The Texas Company

as well as the location of the various measuring and controlling instruments. The chart route requires approximately two hours of their time each morning. This is followed by two one-hour training periods, if the departmental work load permits.

The first training period is devoted to basic or related training. The second period includes instruction and actual work on the instruments. Here the trainee learns to use small tools and develops the know-how and confidence that is so important when servicing the operating equipment. The remaining four hours of the scheduled workday for the trainees is devoted to some kind of productive work within the Instrument Department. It is desirable, if possible, to assign the trainees to field or shop work closely related to their training schedule for that day or week.

Using the previously-mentioned symbols for Type of Training, we have shown what we have found to be the minimum amount of instruction required for the majority of our instrument mechanics.

We have found it good practice to carry the basic (or related) training along with the period on instrument maintenance and repair. The course seems to hold more interest for the trainees when handled in this manner.

SECTION VI

Subject	*Training Period (hours)*	*References (See Appendix A)*
LIQUID-LEVEL MEASUREMENT AND CONTROL:		
1. Float or Cage Type	2D-2L-25F	6, 11, 16, 17
2. Displacement Type 3. Differential Type 4. Boiler Feed-water Level Controls (Types "A," "B" and "C")	2D-2L-25F	6, 11, 16, 17

SECTION VII

PNEUMATIC CONTROL AND PNEUMATIC TRANSMISSION:		
1. Pneumatic Control (a) Type "A" (b) Type "B" (c) Type "C" (d) Type "D" — Check and Calibrate	6D-4L-30F	11, 17
2. Pneumatic Transmitters and Receivers (a) Type "A" (b) Type "B" (c) Type "C" (d) Type "D" — Check and Calibrate	6D-4L-60F	11, 17
3. Electrical Telemetering (a) Type "A" (b) Type "B"	2D-8F	17

SECTION VIII

1. Combustion Controls (Boiler House) (a) Type "A" (b) Type "B" (c) Type "C"	15D-4L-80F	17

SECTION IX

1. Gas Analyzers and Alarms (a) Oxygen Indicators and Recorders (b) CO_2 Recorders (c) % Hydrogen Recorders (d) Combustible Gas Alarms	16D-4L-50F	11, 17
2. Corrosion Control (a) pH Recorders & Controllers (b) Chlorinating Equipment	10D-80F	17
3. Penetron (a) Theory of Operation (b) Routine Service (c) Repair	10D-30F	17

SECTION X

1. Automatic-control Theory and Application (a) Fundamentals (b) "High-sensitivity" (c) "Full-throttling" (d) "Full-throttling" with "Reset" (e) "Second Derivative"	30D-10L-80F	6, 10, 11, 16, 19, 20

APPENDIX A

LIST OF REFERENCE MATERIAL

1. *Safety Manual.* The Texas Company.
2. *Book of Engineering Standards.* The Texas Company.
3. *Elementary Science Applied to Petroleum Production and Refining,* by Heisler. Okla. A and M Book Store, Stillwater, Okla.
4. *Physics Course.* Henry Ford Trade School.
5. *Pyrometric Practice.* National Bureau of Standards.
6. *Industrial Process Control,* by D. P. Eckman. John Wiley & Son.
7. *Flow Meter Handbook, E-2,* American Meter Co.
8. *Flow Meter Handbook,* Brown Instrument Co.
9. *Flow Meter Engineering,* by L. K. Spink. Foxboro Company.
10. *The Texas Company Manual of Testing (Two Volumes).*
11. *Industrial Instruments,* by Thos. Rhodes. McGraw-Hill Pub. Co.
12. *Instruments* (Magazine—Files and Current Issues). Instrument Publishing Co.
13. *Elementary Engineering Electronics,* by A. W. Kramer. Instruments Publishing Co.
14. *Maintenance and Servicing of Electrical Instruments,* by Jas. Spencer. Instruments Publishing Co.
15. *Industrial Electronics.* University State of New York, Vocational Training.
16. *Instruments and Process Control.* New York State Vocational and Practical Arts Ass'n, Delmar Publishers.
17. Manufacturers' Instruction Manuals.
18. *Temperature—Its Measurement and Control In Science and Industry.* Reinhold Publishing Corp.
19. *Fundamentals of Instrumentation,* by M. F. Behar. Instruments Publishing Co.
20. *Automatic Control Engineering,* by E. S. Smith. McGraw-Hill Book Co.

Taylor's ALL 316 STAINLESS STEEL Aneroid Manometer

HERE it is—the famous Taylor Aneroid Manometer—now available in all 316 stainless steel to handle tough corrosives like nitric acid, acetic acid, sulphuric acid, phosphoric acid, caustics. Measures flow, level, or specific gravity. Has all the advantages of the previous model which is still standard for ordinary jobs.

The Taylor Aneroid Manometer has been thoroughly field-tested in wartime chemical and petroleum plants where it earned a proud record for cutting maintenance costs to a minimum. No mercury to replace. No stuffing box. No internal pivots to wear out. Low volumetric displacement for full range differential. Differential pressure is measured by a bellows and transmitted through a torque tube.

Here are a few money-saving advantages you get with the new all 316 Stainless Steel Aneroid Manometer:

No sealing fluids or blowback systems needed because corrosive fluids can be directly introduced into the manometer.

Entire instrument is tough and dependable for long service.

Easy to clean — no etched surfaces — no pockets.

Range changes easily made by changing torque tube with another of a different range.

Available ranges, 20″, 50″, 100″, and 200″ of water differential. Working pressure, 300 psi. Ask your Taylor Field Engineer or write Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada. *Instruments for indicating, recording and controlling temperature, pressure, humidity, flow and liquid level.*

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Instrument Installation *and* Maintenance Practices *in a* Modern Refinery

By GEORGE A. LARSEN, The Texas Company, Lockport, Illinois.

SINCE instruments are a "must" item in the modern refinery, we have felt the need for an organized and independent Instrument Department whose function is to specify, install and properly maintain the plant instrumentation; and whose direct responsibility is to insure accurate and economical operation of this equipment.

In an effort to improve departmental and equipment efficiency we have adopted certain standard practices and procedures which may be of some interest to others. It will not be possible to discuss all of these practices, so only those of major importance will be mentioned.

Shop Facilities

One of the most important Instrument Department requirements is a well-equipped shop, centrally located with respect to the operating units. Good illumination for night or day work is important because a refinery Instrument Department operates on a 24-hour schedule. Our instrument repair shop has excellent natural lighting for day operations, while fluorescent lighting over the worktable provides sufficient illumination for the night shift.

Each instrument mechanic is provided with a locker for tools and personal effects.

The large worktable is covered with ⅛" steel plate to permit the better handling of heavy equipment such as valves and flowmeters. One end of the workbench is equipped with two flowmeter test racks and the necessary manometers, air connections, regulating valves and flexible tubing. Both meter racks are provided with drip pans to catch all spilled mercury.

Safety is an item of primary importance to the Instrument Department personnel. They are instructed in the safe handling of mercury, inflammable liquids and the servicing of flowmeters for hot oil, light hydrocarbon, caustic and acid. Metal safety hats are worn when working in areas where falling objects may cause an injury. Each member is issued a pair of goggles which he keeps available for use when required. Monthly safety gang meetings help maintain interest in the safety program and produce many worth-while ideas.

The shop tool locker includes such special items as pneumatic drill motor, for use in hazardous locations, electric drill motor, pneumatic impact wrenches for valve work, saw gun for panel-board cutouts, rotary saw for circular cutouts, tubing tools and many other similar items commonly used for instrument installation and maintenance.

Personnel and Training

[Editor's Note.—This section of Mr. Larsen's ISA paper was an extremely brief condensation of the article "Instrument Craftsmanship Training Course" which he had written for *Instruments* before writing his ISA paper. This article appears elsewhere in this issue.—M. F. Behar]

Standardized Meter Practices

The standardization of various items and meter piping arrangements has done much toward improving departmental and equipment efficiency. Extra copies of these standard items are kept on file and are always available to all crafts assigned to do an instrument installation job.

Fig. 1 shows our standard wall bracket for flowmeters and transmitters. These are kept on hand as stock items and eliminate the past practice of assigning steel men or pipefitters to mount the instrument, using a bracket of their own individual design. The mounting height is a standard 42" from the floor to the top of the bracket.

Fig. 2 shows a standard type seal pot or trap used in all services except some very special installations.

Fig. 3 shows in detail the construction of our standard mercury and sediment trap used when required.

Fig. 4 shows a special type steam flowmeter condensing chamber especially suitable for low steam pressure services.

Fig. 5 shows a detail of an orifice or pressure tap clean-out device. On connections requiring frequent cleaning these devices are permanently installed as shown.

Fig. 6 shows a typical meter hookup for hot recycle gas oil using the seal chambers as sediment and water traps. With this type of connection the manometers remain clean for long periods

*Originally prepared for presentation at Second Annual Instrumentation Conference of Instrument Society of America, Chicago, September 1947; revised and presented before Peoria, Illinois, Section of I.S.A. February 1948; further revised and edited as an *Instruments* article.

Note: Statements and opinions advanced in papers are to be understood as individual expression of their authors and not those of the Society.

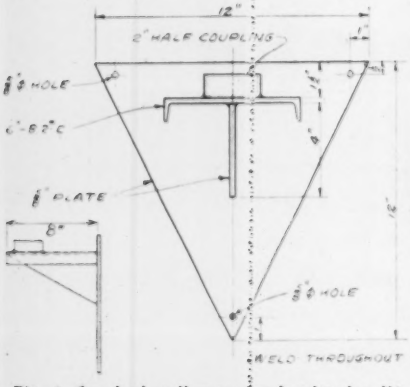

Fig. 1. Standard wall-mounting bracket for differential meters and transmitters.

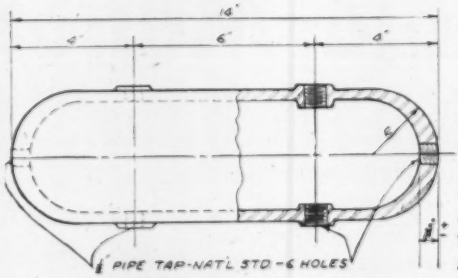

Fig. 2. Standard seal chamber. Made from one piece—ends spun spherical and welded shut from spinning operation. Bosses spun in side. Part No. B-1001 (1500-lb. test) made from 4" Schedule 160 seamless steel pipe. Part No. B-1002 (2000-lb. test) made from 4" Schedule 160 seamless steel pipe.

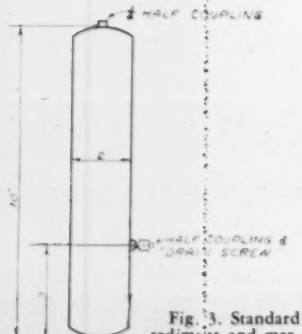

Fig. 3. Standard sediment and mercury trap for differential meters.

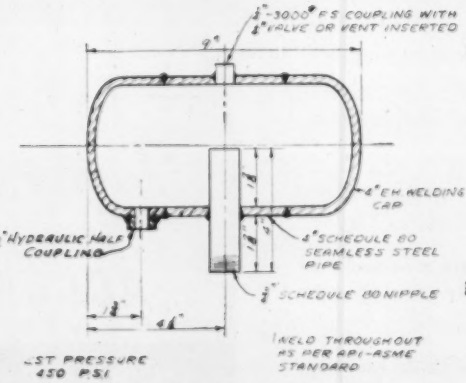
½"-3000# F.S. COUPLING WITH ½" VALVE OR VENT INSERTED
9"
4" E.H. WELDING CAP
½" HYDRAULIC HALF COUPLING
4" SCHEDULE 80 SEAMLESS STEEL PIPE
½" SCHEDULE 80 NIPPLE
4½"
WELD THROUGHOUT AS PER API-ASME STANDARD
TEST PRESSURE 450 PSI

Fig. 4. Condensing pot—steam metering.

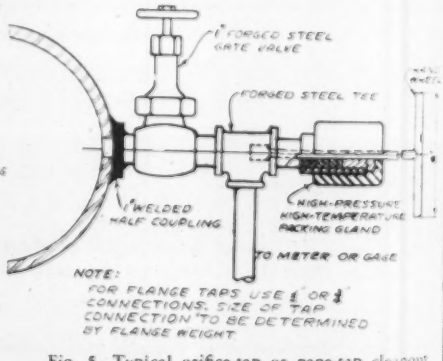
1" FORGED STEEL GATE VALVE
FORGED STEEL TEE
1" WELDED HALF COUPLING
HIGH-PRESSURE HIGH-TEMPERATURE PACKING GLAND
TO METER OR GAGE
NOTE:
FOR FLANGE TAPS USE ½" OR ¾" CONNECTIONS. SIZE OF TAP CONNECTION TO BE DETERMINED BY FLANGE WEIGHT

Fig. 5. Typical orifice-tap or gage-tap cleanout rod or drill.

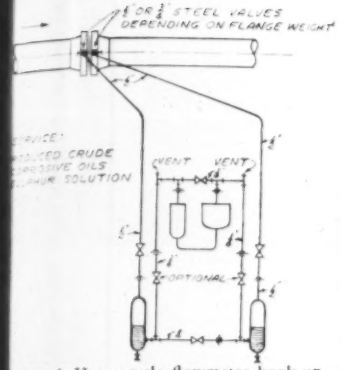

Fig. 6. Hot recycle flowmeter hook-up.

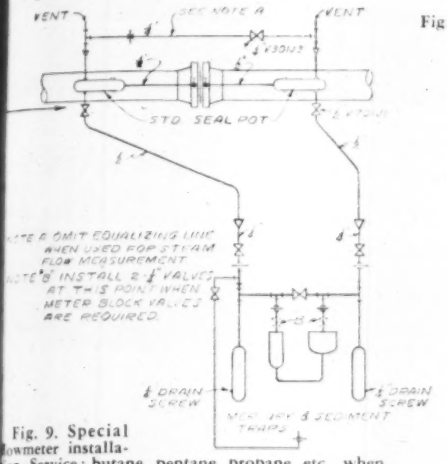
VENT
SEE NOTE A
VENT
STD. SEAL POT
NOTE A OMIT EQUALIZING LINE WHEN USED FOR STEAM FLOW MEASUREMENT
NOTE B INSTALL 2 VALVES AT THIS POINT WHEN METER BLOCK VALVES ARE REQUIRED.
DRAIN SCREW
DRAIN SCREW
MERCURY & SEDIMENT TRAPS

Fig. 9. Special flowmeter installation. Service: butane, pentane, propane, etc., when seal pots are required. Steam—see Notes "A" and "B."

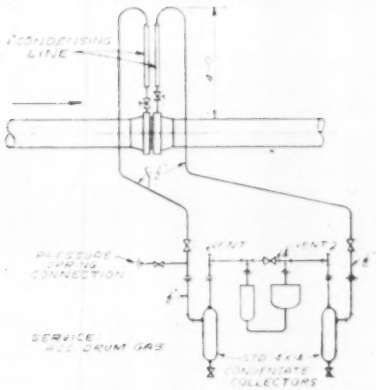

Fig. 7. Installation for metering wet gas.

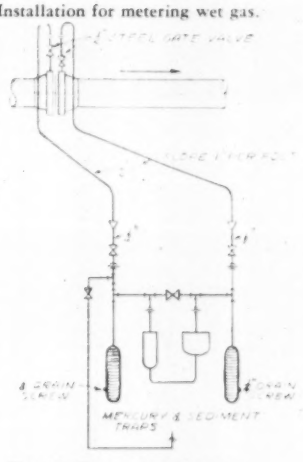

Fig. 10. Dry gas or air meter.

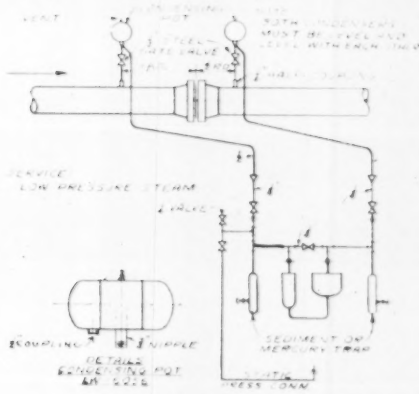

Fig. 8. Low-pressure steam meter.

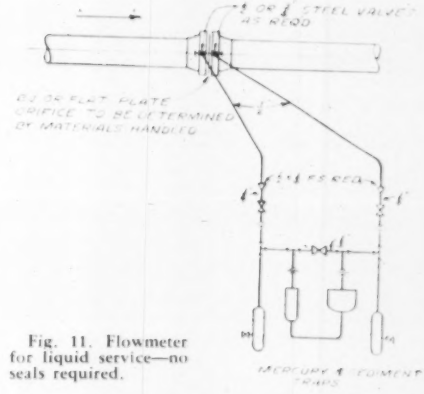

Fig. 11. Flowmeter for liquid service—no seals required.

and are unaffected by sediment and water accumulation.

Fig. 7 shows a typical installation for metering wet gas. Note the four-foot risers above the orifice and condensate collectors below the flowmeter.

Fig. 8 shows a recommended hook-up for low-pressure steam. The top connected condensers with ¾" drain-back lines make the installation simple, economical and quite satisfactory for low-pressure service. Since the line flanges are standard series 15, vena contracta taps are used.

Fig. 9 is an alternate method of connection.

A typical hook-up for dry gas or air metering is shown in Fig. 10. An extra bleeder valve provides a connection for the static pressure check gage.

Meters for fluid measurement not requiring seal pots are connected as shown in Fig. 11.

Numerous types of seals and hook-ups are used in the flow measurement of caustics and acids. Figs. 12 and 13 show arrangements that have proven quite satisfactory.

Fig. 14 shows the method used when it is desirable to install seal pots below the flowmeter.

Orifice Sections

All orifice sections or primary elements receive special attention from the instrument department personnel. A number of special points must be observed and followed if satisfactory results are to be obtained. These key points follow:

1) Carefully check the length of straight pipe preceding and following the orifice. These distances must conform to ASME requirements.

2) Line must be of uniform bore and free of burrs or roughness. Pipe must extend through flanges so there will be no recess between the face of the orifice plate and the end of the pipe. If weld neck flanges are used, the inside of the orifice section must be of uniform bore and free of welding burrs or roughness.

3) Orifice taps for liquid measurement are always made on the side of the line or flanges, while taps for gas, air or vapor measurement extend upward from the line or flanges.

4) The size of the tap may be within the limits of ¼" minimum to ¾" maximum. Line size and service determines this size.

5) The pressure tap must be absolutely flush with the conduit wall and free of burrs or roughness. Microscopic burrs on the hole edge of an orifice tap have been known to produce errors as high as 4 percent.

6) Location of taps: (a) Flange taps 1" upstream and 1" downstream with respect to the face of the orifice plate. (b) Pipe taps should be located approximately 2½ pipe diameters preceding the plate and 8 pipe diameters following the orifice plate. (c) Vena contracta taps require the upstream connection or tap located one pipe diameter from the face of the orifice plate and the down-stream or low pressure tap approximately ½ pipe diameter from the plate. This distance varies slightly with the pipe-to-orifice diameter ratio, generally referred to as Beta or $d:D$ ratio.

7) The $d:D$ ratio should not be permitted to exceed 0.70 nor be less than 0.20.

8) Orifice plates must be carefully centered in the lines to produce correct pressure readings. The plate should be made to fit the bolt circle of the flanges with which it will be used.

9) The orifice edges must be sharp and square. Plate thickness must not be greater than 1/30 of the pipe diameter. On line sizes under 4" the plates made of ⅛" materials are counterbored to the required thickness. This method is preferable to the conventional beveled edge plate that was so often replaced wrong after its inspection.

10) The orifice i.d. must be carefully checked during inspection periods and the handle marked to indicate the last calipered size.

11) Connecting lines between the primary element and the instrument must not be less than ½" and they should be graded at least 1" per foot to eliminate vapor or condensate traps.

12) In the measurement of light hydrocarbons it is important to locate the orifice section at a point lower than the level of the material flowing from a drum or vessel. Flashing of the more volatile materials occurs when the orifice is installed above the mean liquid level.

Calibration Methods

All differential type and mercuryless or force-balance instruments are cali-

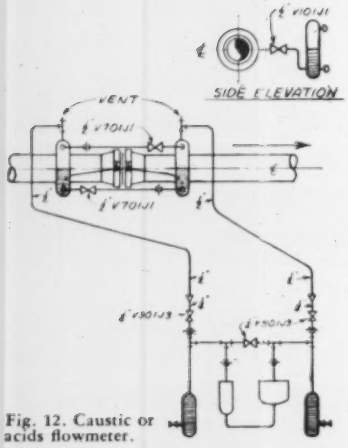

Fig. 12. Caustic or acids flowmeter.

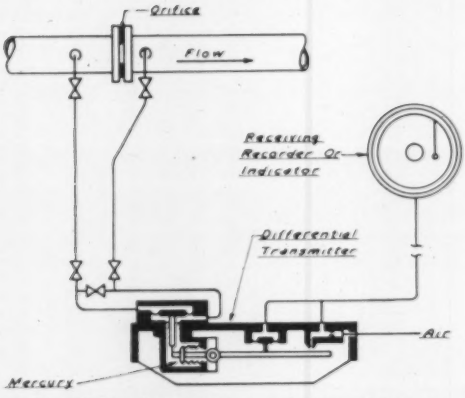

Fig. 13. Special arrangement of differential transmitter, flow measurement system for sulphuric acid service.

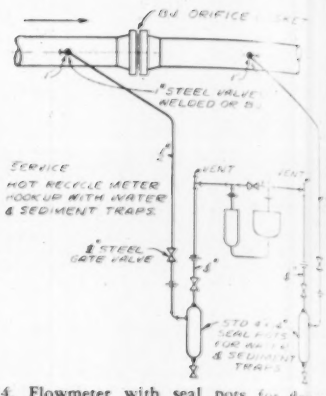

Fig. 14. Flowmeter with seal pots for flowing medium lighter than sealing medium.

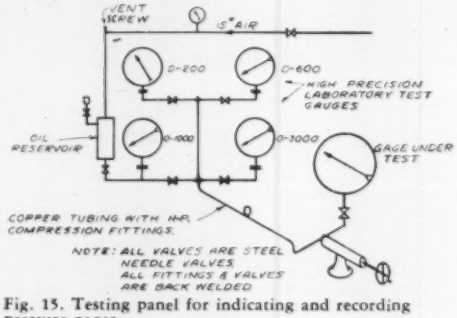

Fig. 15. Testing panel for indicating and recording pressure gages.

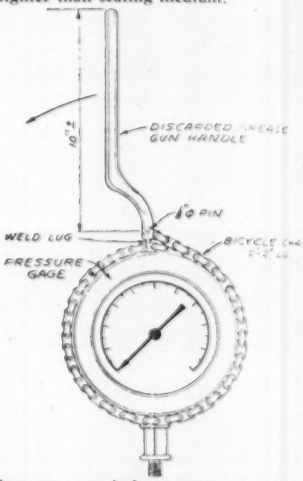

Fig. 16. Spanner wrench for pressure gage covers. (Designed by F. Cauko.)

brated dry using single-column well type manometers of various ranges. Low-range pressure gages and pneumatic receivers are carefully checked by comparison with a precision mercury manometer calibrated in lbs./in.^{2} and tenths. The dial type standard indicating pressure gages are checked by comparison with laboratory test gages. Fig. 15 shows our test panel in detail. The four master gages span the range of 0-3000 lbs./in.^{2}.

The gages are tested periodically with the dead-weight tester which is ordinarily kept under lock and key. With more than three thousand gages in the plant to maintain, this is our method of doing the job quickly and efficiently.

Fig. 16 is a detail of a spanner wrench that assists in the removal of threaded type pressure gage rims.

Potentiometer recorders are quickly and conveniently checked with a series of check coils of fixed values. For checking purposes we replace the cold-junction coil in the recorders with one of these coils of predetermined value. These coils merely supplement our portable testing equipment and are used primarily for determining whether or not the fault lies in the instrument or its external circuit.

Thermocouples made from duplex glass-covered wire are being used quite extensively where temperatures do not exceed 800° F.

Control Valves

The importance of control-valve maintenance must not be overlooked. The control system is no better than its control valves. These devices require perfect alignment, correct packing, proper lubrication, a good diaphragm, correct type of inner valve and must be responsive to slight loading air changes on the diaphragm. A trained instrument mechanic should always be assigned to the maintenance of this equipment.

Control valves of large size or those requiring rapid response or amplified air pressure are equipped with air relays or booster pilots.

Instrument Air Supply

Pneumatic control equipment must have an adequate supply of clean dry air for trouble-free operation. We have made extensive improvements in the instrument air system to provide a satisfactory air supply. Each operating unit is equipped with air scrubbing equipment and auxiliary air compressors to take over in case of plant air failure. These compressors "float" on the air line and cut in at a predetermined minimum air pressure.

Steam Generator Controllers

All steam generators in the boiler house are equipped with automatic controllers primarily to insure maximum fuel economy but also to maintain constant steam pressure. The control system is designed to burn either gas or oil separately or in combination and in any ratio. The steam pressure is held within close limits in spite of the fact that waste heat boilers of varying output on other units in the plant also feed into the plant steam system. Without control on the boilers it would be a difficult problem to maintain constant steam main pressures. The advantages of controlled steam pressures are reflected in fuel saving, better pump and turbine operations and improved process control.

One unique feature of this control system is the use of a specially-designed air relay to permit the operation of two different control systems on one master controller. The air relay has a ratio of approximately 1 to 10.

Another interesting feature of this control system is the safety arrangement that prevents the introduction of more fuel into the furnace than there is air available for burning it. This safety system within the control scheme measures fuel quantities and balances them against air flow quantity in a totalizer which cuts back fuel load ing pressure and increases loading pressure to the air flow controller.

Special Items

Among the numerous special items worthy of mention are the pH recorders and controllers, gas analyzing equipment and the Penetron.

The determination and control of pH is important wherever water or water solutions are used. The modern refinery is continually discovering new benefits and new economies through the utilization of pH instruments. The instrument men are instructed in the servicing of this equipment. A daily check of this equipment is required, at which time the cells are carefully checked with a buffer solution that is verified by the plant laboratory technicians.

The Penetron is an instrument developed by The Texas Company and used in the refinery for the determination of wall thickness of lines, vessels and tanks. It accompishes this function with a high degree of accuracy by the use of penetrating gamma rays. Caibration checks on the operation of the instrument are made periodically in the shop as a routine service practice.

Conclusion

It has not been possible to mention all of the worth-while practices and operating methods used in our Instrument Department, but it is hoped that those presented may contribute something toward the improvement or solution of some of your own instrumentation problems.

Progress Report on Hagan THRUSTORQ

The first announcement of Hagan THRUSTORQ appeared late in 1945.

At that time Hagan THRUSTORQ was already in service in major airplane and automobile engine factories. They were being used for the measurement of torque of standard horizontal engines and of vertical helicopter engines, and the thrust of jet engines.

Since then the use of THRUSTORQ in these fields has increased greatly. More companies have been added to the list of users; more THRUSTORQS have been placed in service by the companies using them; new uses for THRUSTORQ have been developed.

VARIED APPLICATIONS

THRUSTORQS are used today not only for these original purposes and for such allied applications as measuring the thrust of intermittent jet engines (in rockets and buzz bombs, for example) but they are also employed in connection with tests of chassis, valves, bearings and piston rings; in the weighing of liquids; and in many other ways.

MEASURES WITH *AIR*

Hagan THRUSTORQ measures force by automatic application of a measured pneumatic pressure on a precision flexible diaphragm. The measurement is accomplished by no movement of the measured system. This null displacement feature has already made possible the development of several new types of testing machines by users.

Pressures can be registered on a manometer, or gauges may be calibrated to give readings directly in foot-pounds. The location of any gauge or recording device is determined *solely by convenience.*

Our engineers will be glad to give you full information concerning any type of application in which you are interested.

HAGAN CORPORATION, HAGAN BUILDING, PITTSBURGH 30, PA.

HAGAN
HALL
BUROMIN
CALGON

HAGAN THRUSTORQ
measuring thrust and torque *with air!*

Kick-Coil Operation *of* Impulse Registers *or* Counters

By RONALD L. IVES, Indiana University, Bloomington, Indiana

Introduction

OPERATION of conventional recording* equipment from a distant contacting instrument† such as an anemometer, by a direct line and battery connection, or by use of either an interposed relay or a vacuum tube circuit, is a simple and straightforward engineering procedure when line and environmental conditions are reasonably good.

As line conditions deteriorate and the environment becomes unfavorable, use of neon-tube "static drains" and r-f. chokes,[1] in conjunction with relay-capacitor[2,3] or vacuum-tube time-delay devices, is usually desirable, and makes possible dependable recording* through ordinary urban or industrial electrical "noise." Use of conventional R-C spark absorbers[4,5] prevents the recording installation from raising the general noise level.

When operating conditions verge upon the "impossible" and line improvements are not feasible, satisfactory operation of the recording* circuit may still be attained, in many instances, by use of several expedients. Simplest and best-known of these is to convert the instrumental signals into a.c., by means of a local battery and local alternator (such as a microphone hummer); to transmit the signals as a.c., and to receive them by means of a tuned amplifier—with time-delay "judgment," if necessary, to eliminate the effects of most line imperfections and extraneous electrical "noise." This method requires a remote battery, but performs well under a wide variety of "difficult" conditions, and permits transmission of several signals over a single line.[6]

When a remote battery will not function dependably, because of chemical or radioactive contamination of the instrument site, or cannot be changed when run down, various methods of operating a recorder by measuring changes in line drain may be employed. One of the best of these is the use of a "kick coil" at the near (recorder) end of the line. This procedure, first developed as a method of last resort, furnishes a practical solution to many recording problems.

Kick-Coil Recorder Operation

General Principles.—When a circuit consisting of an iron-cored inductance, a battery, and a switch, is closed, the core of the inductor is magnetized, the field quickly attaining maximum strength. When the circuit is broken, this magnetic field collapses quickly, inducing currents in the windings. This is the most common cause of contact sparking; and this induced current is normally absorbed by a resistor-capacitor spark absorber to lengthen contact life and to prevent radio interference.

If a second winding is placed on the core, currents of one polarity will be induced in it as the magnetic field is built up (circuit closes); and currents of the reverse polarity will be induced as the magnetic field collapses (circuit opens). When no change takes place in the magnetic field, no current is induced in the second winding.

In consequence, if the primary of a transformer is connected in series with a battery and an interrupter (instrument with make and break contacts, such as an anemometer), current of one polarity will be induced in the secondary on each "make"; and of the opposite polarity on each "break." Many automotive ignition systems operate on this same general principle.

Simple Triode Application. — Wiring diagram of a simple triode application of the kick-coil receiver is shown in Fig. 1. The instrument here shown is a contacting anemometer, which is at the far end of the line. Successful operation over field wire lines more than twelve miles long, resting directly on the ground, in a saline environment, has been obtained. Protective devices consist of radiofrequency filters and neon-tube static drains. No spark absorbers are necessary in this installation, as the induced currents which would normally produce sparks are removed by the secondary coil and used as operating impulses.

The transformer characteristics are not critical. When the battery voltage is six, a 110/220-0-220 replacement type transformer, with the line connected to the primary, is quite satisfactory. Use of a high-grade transformer in this circuit is not advisable, as a somewhat reluctant core attenuates high-frequency disturbances.

In operation, induced currents of the correct polarity pass through the diode, and charge capacitor C_1. Circuit characteristics are so chosen that the charge on C_1 (positive) becomes great enough to offset the bias of the triode only when the line circuit is opened. Minor charges, resulting from line noises, are drained away by R_2.

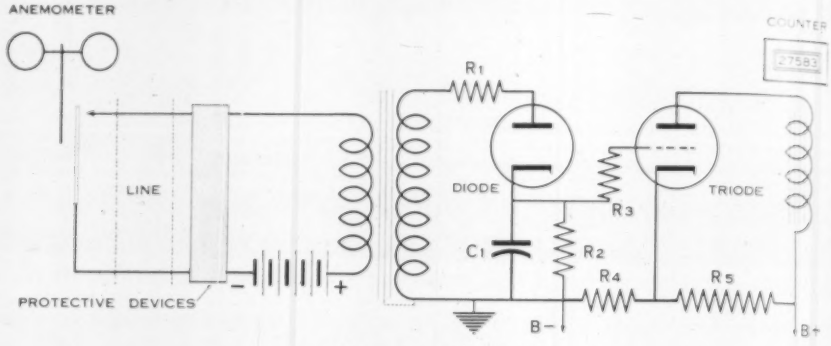

Fig. 1. Simple triode circuit.

The triode is biased beyond cutoff. When this bias is offset by the charge on C_1, the tube draws plate current, the counter is actuated, and the charge on C_1 is dissipated. The resistor R_3 slows this dissipation so that the counter can operate fully.

As shown (Fig. 1), cathode bias is attained by use of a bleeder, evaluated at approximately 100 ohms per plate volt. Section R_5 must be rated to carry bleeder current only: section R_4 needs a higher rating, as it carries both bleeder current and plate current of the triode. A-c. operation of this plate circuit is entirely practicable.

In a few instances, a "depeaking" resistor, R_1, in the diode circuit, will be found desirable. Within a wide range of contact closure frequencies, the time of energization of the counter will be substantially constant. When this time is critical (not a common condition), it can be held constant within approximately one percent by shunting a voltage regulator tube across the transformer secondary.

This circuit is extremely flexible; and can be made to work dependably under a wide variety of conditions, with almost any standard components. An early model functioned satisfactorily using a 6H6 diode and a 210 triode. Later models, using a 117N7-GT tube and raw a.c. on the plate required a simpler plate supply and were equally satisfactory.

Numerous modifications of the fundamental circuit, to suit special needs, are possible, and, in general, are so obvious that description is unnecessary. On one installation, where power economy was

*Editor's Note.—The author does not mean the usual ("curve-drawing" or "chart" or "graphic") *recording*, but registering or counting or integrating. The "recorders" in this article are commonly known as magnetic counters or electrical counters. —M. F. Behar.

†Editor's Note.—Similiarly, this would be the "primary device" or the "transmitter."—M.F.B.

essential, a cold-cathode rectifier was substituted for the diode, and a sensitive relay for R_2.

Blocking Oscillator Applications—When triode plate current needs exceed

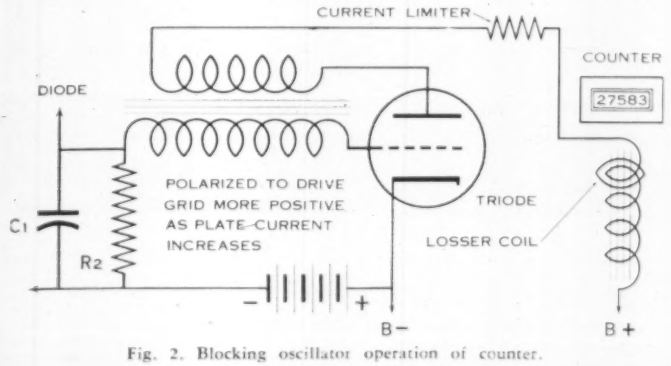

Fig. 2. Blocking oscillator operation of counter.

that conveniently obtainable with the "straight" triode circuit, a triode connected as a blocking oscillator[7] may be employed, as in Fig. 2. This is a standard application, but care must be used, in practice, to limit the plate current to a safe value, and to guard against plate circuit vagaries produced by motion of the counter armature. Plate current may be limited to a safe value by use of a series resistor (current limiter, Fig. 2); and unwanted plate voltage fluctuations, produced by the operation of the counter, may be reduced to a negligible value by use of a losser coil, consisting of one or more shorted turns wound directly over the counter coil.

Extreme efficiency may be obtained, with this circuit, by judicious overvolting of the triode plate. If this is carried too far, however, the mechanical stresses produced within the tube will fatigue the element supports, eventually, and often rapidly, leading to their failure, with resultant shorting of the elements and consequent damage (often spectacular) to the other circuit elements. In practice, overvolting is best used only on "one-shot" devices, such as proximity fuzes, where component life need only be a few seconds.

Thyratron Operation.—Quite obviously, a thyratron, or other gas triode, can be used in place of the high-vacuum triode in Fig. 1, if some means is provided to interrupt the plate circuit after the desired function is performed. Simplest method is the use of raw a.c. for plate supply. Two other simple methods of interrupting the plate current are shown in Fig. 3. In A, which is suitable for use when the time between operations very greatly exceeds the time necessary for an operation, the counter is operated, through the thyratron, by the energy stored in the capacitor. When the voltage on the capacitor drops to the extinction voltage of the tube, no more plate current can flow. The capacitor then recharges, slowly, through a high resistance, from the plate battery. An electromechanical method of opening the plate circuit is shown in B. Here, a contact, actuated by the counter armature, opens the circuit when the armature has completed its swing. A capacitor from battery side of the counter to ground is sometimes desirable to insure a clean break of the circuit.

Whenever the incoming signal is substantially "clean," so that discrimination between line noise and signal is not necessary, the use of the kick-coil and diode circuit is not necessary, and the conventional "make and break" circuit[8] will be found more suitable.

Use of Submultipliers and Step Counters.—Where the frequency of incoming impulses is such that direct operation of a counter is inconvenient or impracticable, any conventional step counter or submultiplier may be operated from the kick-coil and diode circuit, either directly, or through a buffer tube. In general, when incoming signals are unequally spaced, electromechanical submultipliers, composed of either ratchet relays or stepping switches, will be found suitable when the average frequency is less than one signal per minute[9]; and various thermionic submultipliers will be found useful as the frequency of incoming signals increases. Care must be exercised in the selection of a vacuum-tube submultiplier, however, for many of those found most useful for operation from equally-spaced impulses (such as television counters) are virtually useless when the impulses have an unequal or random spacing.

Application to Capacitor-discharge Recorders.—Many of the relay-operated capacitor-discharge recorders developed during the recent war can be adapted for silent and nearly trouble-free vacuum-tube operation by use of a transformer. Although these recorders take many forms in their adaptations to special uses, the general principles involved are similar, and one illustration will suffice to show the general method of adaptation.

Summary circuit of the Grinnell Recorder,[10] widely used by the Chemical Warfare Service, is shown in Fig. 4. In this device, capacitor C_1 is charged from the battery each time the control circuit (not shown) is closed, and is discharged into C_2 each time the control circuit opens. C_2 discharges continually through an instrument, having resistance R_m. In consequence, current through the instrument is a function of rate of contact closure in the control circuit. This rate is not quite linear, as C_1 does not discharge to zero at each transfer, but to the voltage across C_2. A part of this nonlinearity may be eliminated by use of a "depeaking" resistor, R_1. Calibration formula for this recorder ($R_1 = 0$) is :—

$$I_m = \frac{1000\, C_1\, F\, E_2}{1 + C_1\, F\, R_m}$$

in which: I_m = instrument current in milliamperes

C_1 = impulse capacitor capacitance in farads

F = contact closure frequency (number per second)

E_2 = battery voltage

R_m = instrument resistance in ohms.

Time constant of the recording circuit is determined by the capacitance of C_2, which is usually about 1,000 times C_1 in anemometric work. (Other constants for this application are: $I_m =$

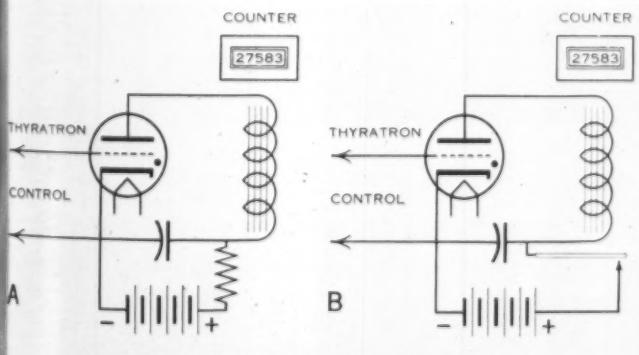

Fig. 3. Thyratron operation of counters.

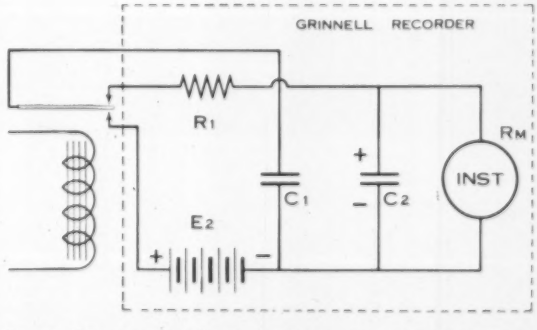

Fig. 4. Summary circuit of the Grinnell capacitor-discharge recorder, originally developed for meteorological use. Figure from Chemical Warfare Service.

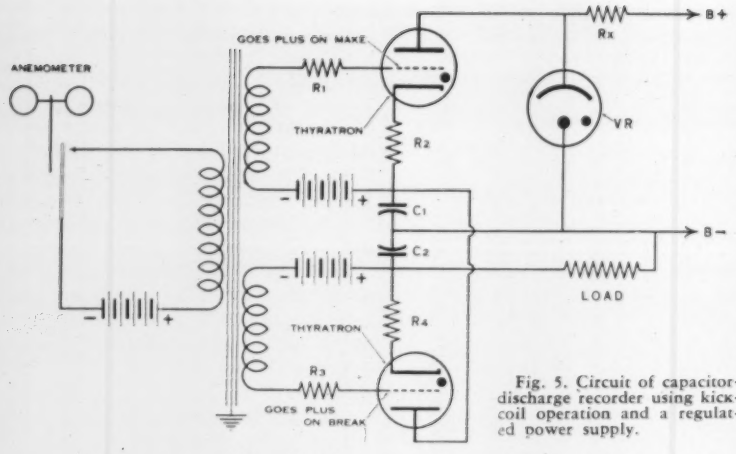

Fig. 5. Circuit of capacitor-discharge recorder using kick-coil operation and a regulated power supply.

0-1 ma.; $C_1 = 4$ mf.; $E_2 = 45$ volts; $R_m = 1{,}000$ ohms). As the d-c. resistance of the smoothing capacitor C_2 is usually low, particularly when an electrolytic capacitor is used, the value of R_m must be corrected for it.

One method of adapting the capacitor-discharge recorder for vacuum-tube operation, using a "kick-coil" coupling, is outlined in Fig. 5. This is only one of a large number of possible adaptations. In this arrangement, impulse capacitor, C_1 (which corresponds to C_1 in Fig. 4) is charged from the regulated power supply through a thyratron whenever the anemometer contacts "make." Use of a large negative bias on the thyratron makes the recorder relatively insensitive to unwanted "noise." Where operating conditions are bad, a diode-capacitor-resistor circuit may precede the thyratron, giving the circuit some additional "judgment," but adding fallible components.

When the anemometer contacts open, the second thyratron fires, charging C_2 from C_1. Smoothing capacitor C_2 is continually "bled" by the load resistance, which corresponds to the instrument resistance of Fig. 4. With this circuit, the impulse capacitor is not charged to the full supply voltage, but to this voltage less the "transfer drop," which approximates the value of the supply voltage less the extinction voltage of the first thyratron. Likewise, the impulse capacitor (C_1) does not discharge to the voltage on the smoothing capacitor (C_2), but to a higher voltage approximately equal to the voltage on C_2 plus the extinction voltage of the second thyratron.

Resistors R_1 and R_3 in this circuit are grid current limiters: resistors R_2 and R_4 protect the capacitors against the surges incident to beginning of power transfers.

Because the voltage surge applied to the grid of the first thyratron is usually much less than that applied to the grid of the second, owing to the absorptive properties of the closed primary circuit on "make," grid bias voltages must be adjusted independently

Practical limits of a recorder of this type, using commercial components, are approximately from two cycles per minute (at lower values cumulated leakage becomes a problem) to three hundred cycles per second (above which "the transformer core won't follow"). No great error is introduced by randomness of impulse distribution within these ranges. If an "audio" transformer is used in place of a "power" transformer, the upper frequency limit may be raised.

Note that the electrical function of the thyratrons in this circuit is analogous to that of the charging diodes in some television counters, and that, for some applications, the simpler diode circuit will perform adequately.

Conclusions

Use of "kick-coil" coupling between a contacting instrument and a recorder makes possible operation under extremely difficult environmental conditions. Because a vacuum-tube circuit suitably coupled to a "kick-coil" functions on only *one* type of change in the control current (increase *or* decrease, *not both*), this arrangement may be used, in many instances, to eliminate time-delay components; and if two secondaries are used (as in Fig. 5), two operations in sequence may be performed for each contacting cycle in the primary circuit.

Independent simultaneous operation of a number of circuits is possible by use of separate secondaries, or, in extreme cases, of separate transformers. Numerous other modifications and applications of this general principle are possible.

Although the current trend is toward the replacement of all electromechanical components by vacuum tubes, environmental conditions sometimes require the reverse. Simple or polarized relays can be substituted for vacuum tubes, or groups of them, in all of the foregoing circuits, and will function in all of them, although usually within a relatively narrow-range of frequencies. Such a "retrogressive" substitution is economically desirable when the phenomenon to be recorded is of relatively infrequent occurrence, so that the recording device is in "productive" operation for only a small percentage of the time.

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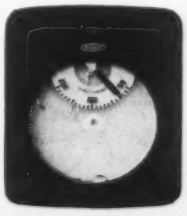

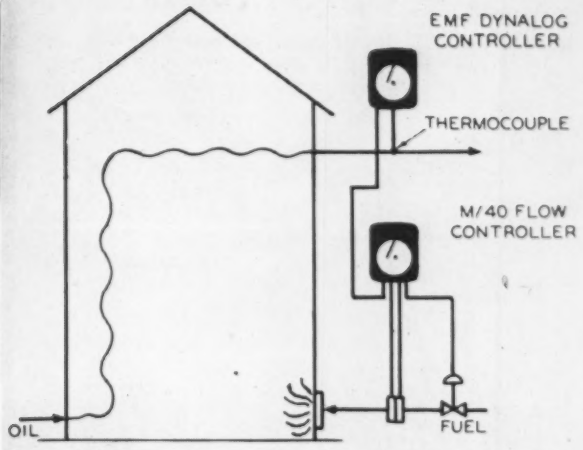

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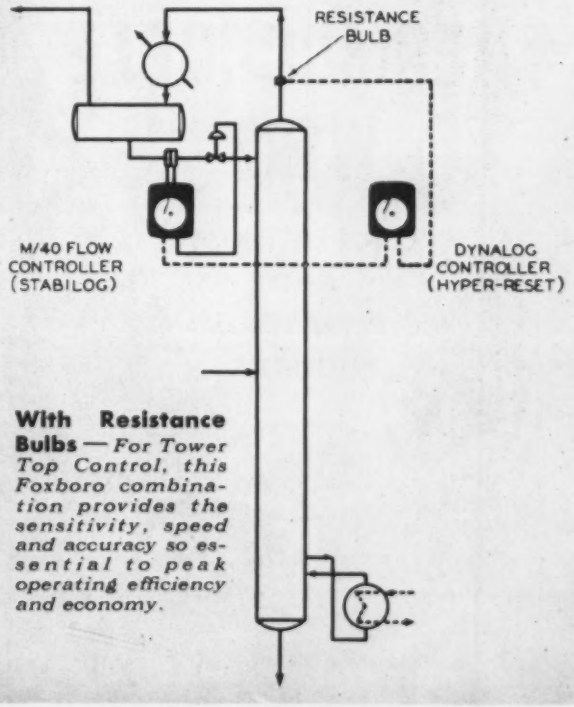

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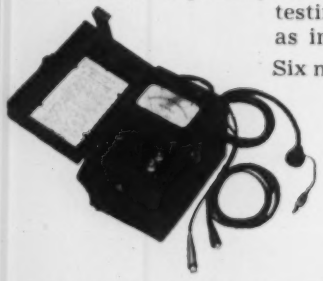

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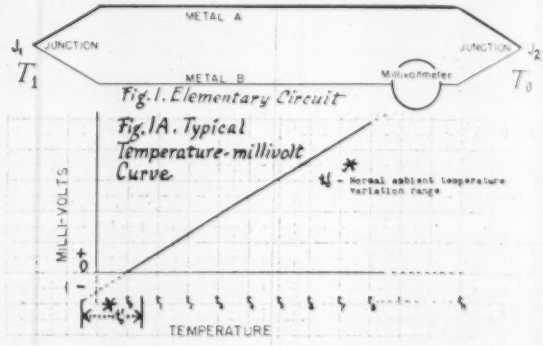
Compensating Millivoltmeter Pyrometers for Ambient Temperature Changes

By R. H. GRANT, Material Engineer, and J. T. CATALDO, Electrical Engineer, Material Laboratory, New York Naval Shipyard, New York.

IN a thermoelectric-pyrometer circuit, Fig. 1, the cold-junction compensation method most widely accepted utilizes a bimetallic spring which automatically shifts the mechanical zero of the millivoltmeter as the ambient temperature (t_2) changes.

Although this is a simple, inexpensive and, in most cases, a satisfactory method, it does not provide 100% compensation over the entire temperature-indicating range of the instrument. This is particularly objectionable where the ambient temperature (t_2) varies widely.

Let us take the simple type of pyrometer consisting of a thermocouple and a millivoltmeter correctly adjusted and



calibrated but without compensating or "swamping" resistance. If this pyrometer was calibrated for an ambient temperature of 25°C. (77°F.) and is used at this ambient temperature, it will correctly indicate the temperature T_1 (Fig. 1) of junction J_1.

The thermo-emf. is proportional to the temperature difference between junctions J_1 and J_2, or

$$\text{mv.} \propto (T_1 - T_0) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

But when $T_0 = 25°\text{C.}$,

$$\text{mv.} \propto (T_1 - 25) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

This temperature-millivolt relationship being non-linear, its expression gives no definite values to work with.* However, examination of the millivolt curve, Fig. 1A, discloses that for relatively small increments of temperature no serious errors will be encountered if the relationship is regarded as linear. Therefore, it is possible to express the relationship in the following manner:

$$\text{mv.} = k_1(T_1 - T_0) + k_2(T_2 - T_1) + \ldots k_n(T_n - T_{n-1}) \quad . \quad (3)$$

where: $k_1, k_2, \ldots k_n$ = millivolts per degree within the limit defined by T_0, T_1, etc.

However, inasmuch as changes in ambient temperature affect only that portion of the curve covered by T_1 to $-T_1$, we will combine all other factors into one expression Σt_n or $\text{mv.} = k_1(T_1 - T_0) + \Sigma t_n$ when $T_0 = 25°\text{C.}$

$$\text{mv.} = k_1 T_1 - 25k_1 + \Sigma t_n \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Assuming that the ambient temperature has been reduced

The opinions or assertions contained herein are the private ones of the authors and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

*If the relationship between temperature and millivolts were a straight-line function, the left and right hand members of Equation (2) could be equated by the use of a constant. Unfortunately, this is not the case.

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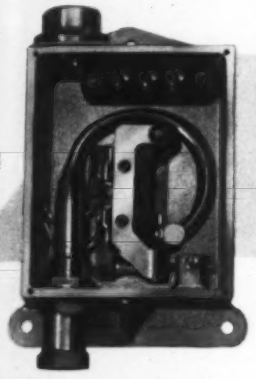

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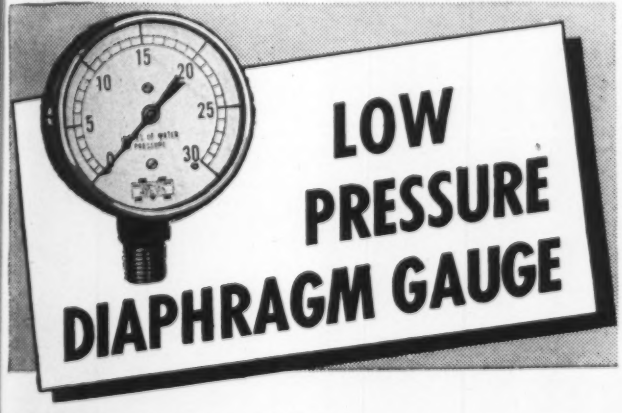

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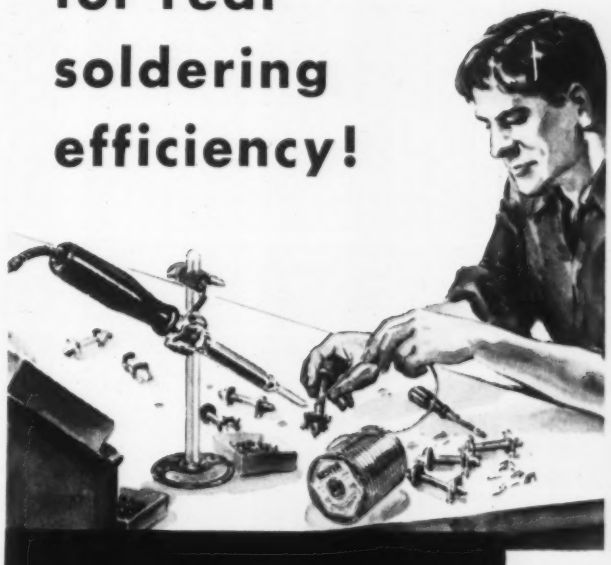

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to $-25°$C. and that temperature t_a remains the same, the thermo-emf. now becomes:

$$\begin{aligned} \text{mv.}' &= k_1 (T_1 - T_0) + \Sigma t_a + k_0 (T_0 - T_0) \\ \text{mv.}' &= k_1 T_1 - 25k_1 + \Sigma t_a + k_0 (T_0 - T_0') \\ \text{mv.}' &= \text{mv.} + k_0 (T_0 - T_0') \\ \text{mv.}' &= \text{mv.} + k_0 [25 - (-25)] \\ \text{mv.}' &= \text{mv.} + 50k_0 \end{aligned} \quad \ldots \quad (5)$$

In comparing Equation (5) with Equation (2), it is seen that the instrument will indicate 50°C. high, owing solely to the decrease in ambient temperature. This 50° error is only part of the result of changing the ambient temperature. The millivoltmeter being a permanent-magnet moving-coil instrument, the torque developed by its moving system to overcome the spring torque is proportional to the current flowing through the moving coil. This current can be expressed as follows:

$$I_{25} = \frac{\text{mv.}}{R_{25}} \quad \ldots \quad (6)$$

where: I_{25} = milliamperes at 25°C.
mv. = millivolts at instrument terminals (25°C.)
R_{25} = resistance of instrument at 25°C.

$$I_{25} = \frac{k_1 (T_1 - T_0) + \Sigma t_a}{R_{25}} \quad \ldots \quad (7)$$

The electric circuit of the instrument is composed principally of copper wire which has a positive temperature coefficient. Hence, when the ambient temperature is decreased to $-25°$C., the resistance of the circuit decreases:

$$I_{25} = \frac{\text{mv.}}{R_{25}} = \frac{k_1 (T_1 - T_0) + \Sigma t_a}{R_{25}} \quad \ldots \quad (8)$$

The current at $-25°$C. ambient temperature would be:

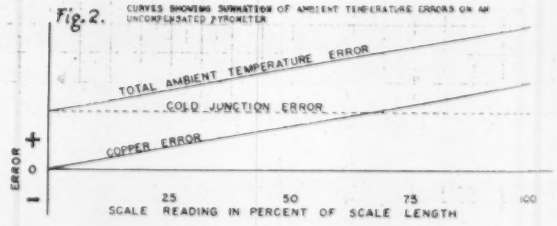
$$I_{-25} = \frac{\text{mv.}'}{R_{-25}} \quad \ldots \quad (9)$$

$$I_{-25} = \frac{\text{mv.} + 50k_0}{R_{-25}} = \frac{\text{mv.} + 50k_0}{R_{-25}\,(0.8075)} \quad \ldots \quad (10)$$

These equations are expressed in their simplest form, assuming negligible change in lead resistance and ignoring voltage drop in the leads.

Comparing Equation (10) with Equation (8), it is obvious that the current I_{-25} at $-25°$C. and hence the deflection of the instrument, is greatly increased because of (a) the increase in thermo-emf.; and (b) the decrease in resistance of the instrument circuit.

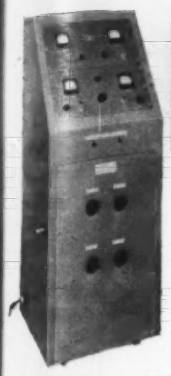
A graph of these effects is shown in Fig. 2. The Cold



Junction Error can be corrected by shifting the mechanical zero of the millivoltmeter as described above. This leaves the Copper Error as the total error of the system. Taking the temperature coefficient of resistance of copper as 0.00385 per °C., it is evident that this copper error amounts to 0.385% per °C. change in ambient temperature. Thus a 10°C. change would produce an error of 3.85%.

To reduce the Copper Error, a series resistance, wound of a "zero" temperature coefficient material, is introduced in the circuit in series with the moving coil. A simple calculation discloses that if 50% of the total resistance of the instrument is composed of copper and 50% of "zero" temperature cofficient wire, the effect of a change in ambient

**It may be of interest to note that if $\Sigma t_a = 0$ and T_0' is sufficiently close to T_0 for the slope to be linear, then $k_0 = k_1$ and $\text{mv.}' = k_1 (T_1 - T_0')$



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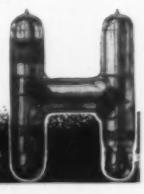

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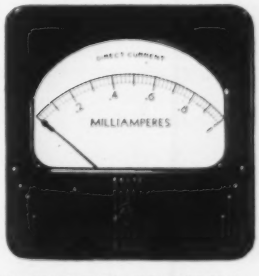

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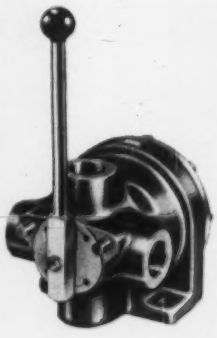

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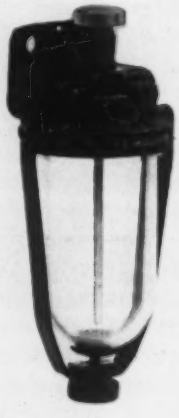

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temperature will cut the slope of the Copper Error curve in half. It would be convenient if the entire instrument circuit could be made of such wire; but thermo-emf. being of the order of millivolts, if the inserted resistance exceeds a certain value, we shall no longer obtain sufficient current to operate the indicator.

Although the indicator can be made to operate on less current by reducing the spring torque and by increasing the number of turns of wire on the moving coil, spring torque can be reduced only a certain amount before the torque-to-weight ratio falls below a safe value and poor performance results. Increasing the number of turns adds weight and copper resistance if the same size wire is used. If, because of space limitations in the air gap, adding turns necessitates the use of a smaller size wire, the copper resistance will increase greatly, defeating the purpose of the added turns. The design of an instrument is a compromise. It may be noted that in recent years instrument sensitivity has been greatly increased, without increasing the number of turns or decreasing the spring torque, by the use of improved magnet materials such as colbalt, Alnico, etc.

It would be convenient if the ratio of "zero" resistance temperature coefficient wire to copper would be the same for all instruments. This is impossible, as this ratio will depend upon the temperature range of the instrument and the type of thermocouple used.

From the above it is apparent that the use of a bimetallic spring and of "zero" resistance coefficient wire does not provide 100% compensation; also that the ambient temperature error will be small at the beginning of the scale and greatest

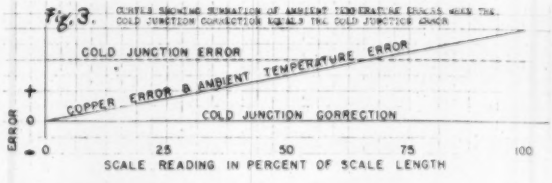

Fig. 3. CURVES SHOWING SUMMATION OF AMBIENT TEMPERATURE ERRORS WHEN THE COLD JUNCTION CORRECTION EQUALS THE COLD JUNCTION ERROR

at the upper end of the scale. See Fig. 3. Therefore it is customary to have the bimetallic spring over-compensate the Cold Junction Error in such a manner that the combined Cold Junction and Copper Errors are 100% compensated at approximately half-scale. See Fig. 4.

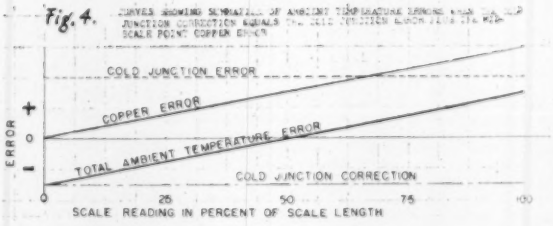

Fig. 4. CURVES SHOWING SUMMATION OF AMBIENT TEMPERATURE ERRORS WHEN THE COLD JUNCTION CORRECTION EQUALS THE COLD JUNCTION ERROR AT THE MID-SCALE POINT COPPER ERROR

With poorest compensation at the ends of the scale, it is logical, in selecting a pyrometer for use where ambient temperature varies widely, to select a range such that the nominal operating temperature will be indicated at approximately mid-scale. It has been suggested that indicating pyrometer systems be rated, as to accuracy, by stating the maximum allowable ambient-temperature error in degrees for the second and third quarters of the scale and a greater allowable error (approximately twice as much) for the first and fourth quarters of the scale.

The ambient-temperature error is not the only or main source of inaccuracies: The millivoltmeter will be subject to the usual errors of such an instrument, depending upon the care and precision with which it is constructed. Generally speaking, a switchboard type will be a nominal 1% instrument, while a portable type will be a ¼% to ½% instrument.

Another source of error is the imperfect interchangeability of thermocouples. These are manufactured from selected materials which conform to the within reasonable limits (usually ±0.5%). Thus, when using one indicating instrument and two thermocouples to measure the same temperature,

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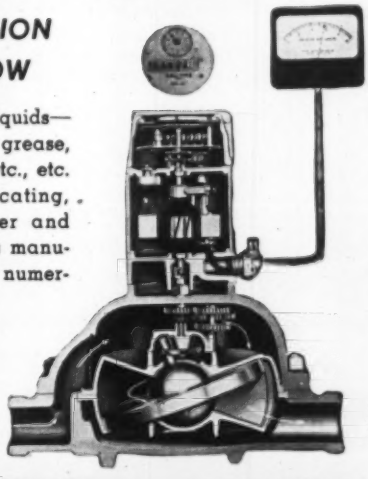

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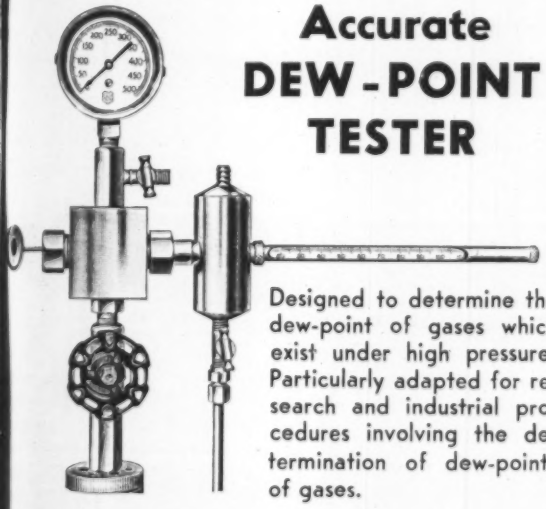

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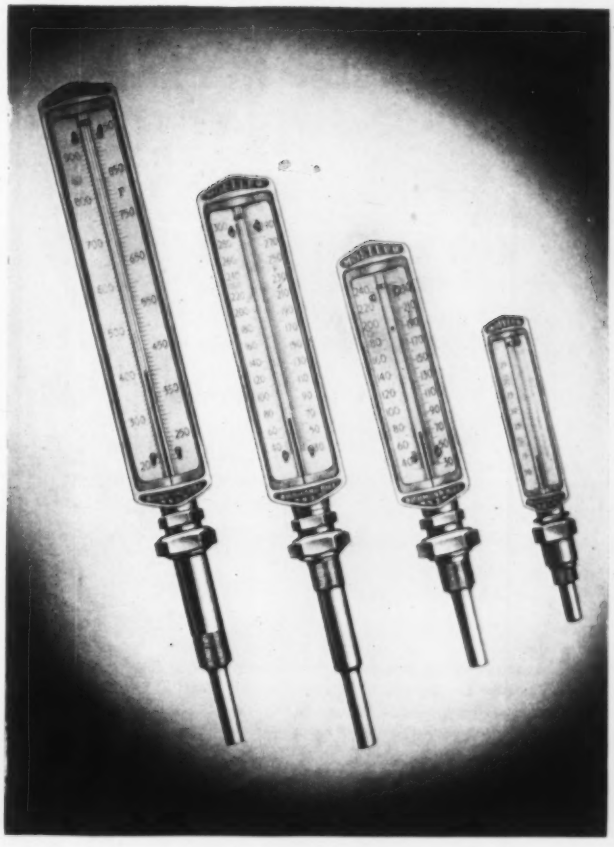

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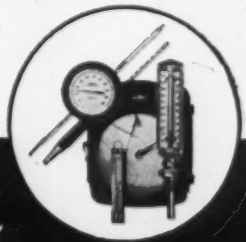

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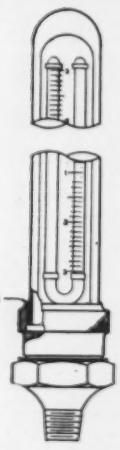

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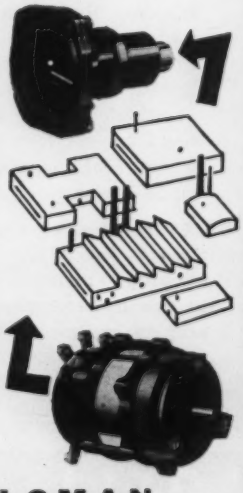

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difference of 1.0% could be obtained between readings. Furthermore, not all manufacturers use the same millivolt vs. temperature curve when calibrating instruments or producing thermocouple wire.

Any appreciable change in the resistance of the connecting leads can introduce a serious error, because the instrument is normally calibrated for a definite external lead resistance.

The user must be on guard to insure that the "cold junction" of the system is at the same temperature as the automatic compensator.

The insertion of foreign material in the leads is likely to introduce additional junctions or thermocouples, all possibly at different temperatures, the resultant emf. being incorrect and the indication of the instrument meaningless.

Finally, the authors may mention that they have come across many instances where an operator was using thermocouples made of other base metals than the thermocouples for which the indicating instrument was originally calibrated.

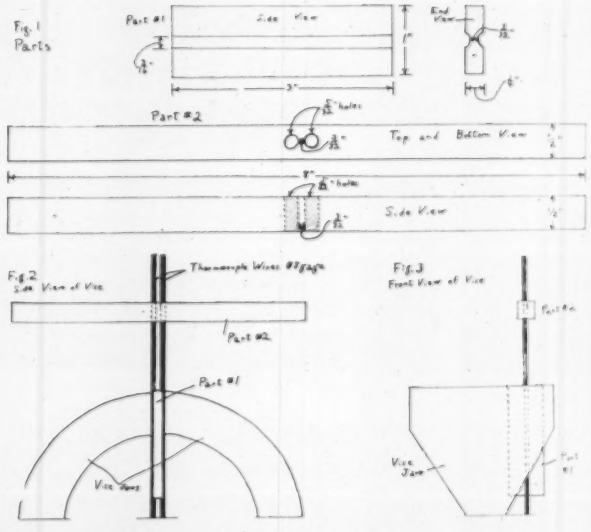
From the foregoing, it might appear that temperature measurements with an indicating pyrometer are subject to large errors. This is not the case. Manufacturers minimize all possible source of errors within their control. In the final analysis, however, the greatest responsibility rests upon the operator.

In conclusion, it might be well to point out that lead resistance errors and copper errors do not exist in pyrometer systems using a potentiometer or null indication. Also, errors due to scale marking are greatly reduced.

Thermocouple-wire-twisting Fixture

By SIDNEY SPUNGIN, Springfield, Mass.

TWO easily-made parts greatly simplify the job of twisting the ends of #8 gage thermocouple wires prior to welding. Also, this device will properly space the wires adjacent to the twist, so that the porcelain beads can be easily pushed right up to the end of the thermocouple. Fig. 1



gives the dimensions of the parts. Figs. 2 and 3 show how to use them. The thermocouple wires are placed in the grooves of part #1 and squeezed together in a vise. Part #1 now acts as a spacer between the wires. Leave about three inches of thermocouple wire above the vise. Then place part #2 over the ends of the thermocouple wire and bring down to within 1½" of the vise. Rotate part #2 about two complete turns and then remove by lifting up. Cut off surplus wire, loosen vise and remove spacer (part #1). The thermocouple is now ready to be welded.

Shop Kinks continued on page 456

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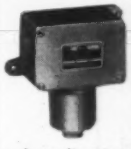

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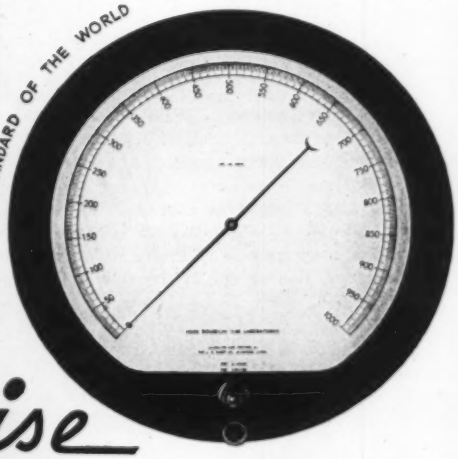

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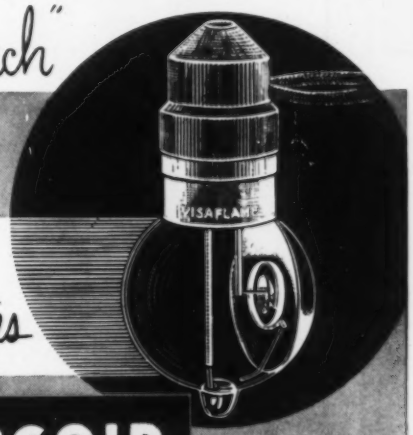

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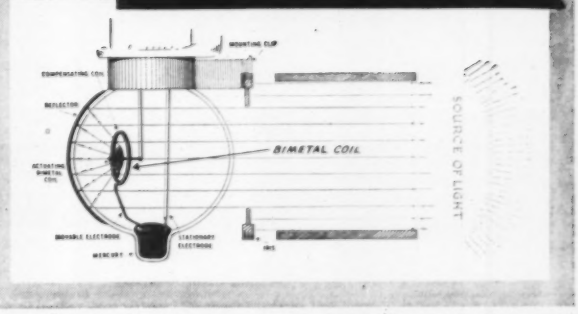
VISAFLAME



No. 15—The Visaflame Control, Mercoid Corp.

The Visaflame Control, product of the Mercoid Corp., is an unusual application of Chace Thermostatic Bimetal. Contrarily, this burner control is placed where it is actuated by the light of the oil burner flame—*not* the heat. Diagram shows light rays from the fire reflected and focused on the small bimetal actuating coil. The coil absorbs the light waves and they are converted into a form of heat energy. The bimetal coil then rotates, the movable electrode moves into the mercury pool and contact is closed. In the absence of light, the circuit opens. Changes in heat *surrounding* the Visaflame do not affect its operation due to a separate compensating bimetal coil.

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Circular Glass Cutting

By JOHN F. HOGSETT, Monaca, Penna.

INSTRUMENT Maintenance Men frequently have to cut glass in a variety of circular sizes as it is impractical to stock factory cut glass in all diameters needed for pressure gages, round-case recorders, etc. If the following method is used perfect circles can be cut from glass without screening or grinding except possibly to remove sharp edges in order to prevent someone getting cut.

First: Make sure the glass is resting flat on a solid surface with no dirt underneath. Be sure to use a sharp glass cutter and do not go over a scribed line with a cutter as this will dull the cutter wheel. Single-strength glass is thick enough for most purposes but if stronger glass is wanted or the size is quite large, use double strength glass.

Second: Scribe the glass with a circular glass cutter which has been set to the proper size. Be sure to leave a minimum of approximately ¾" of excess glass all around.

Third: Turn the glass over and, with the *handle* end of a straight glass cutter, tap above the scribed circle until the glass cracks all the way through. Do this all the way around the circle.

Fourth: Turn the glass to the original side. With a straight glass cutter, scribe four (more for larger sizes) lines on the glass from the circle to the outside of the waste portion. Again turn the glass to the reverse side and tap over these last scribed lines.

Fifth: Hold the glass firmly in both hands with the original side up. With the scribed lines approximately centered over the edge of a bench or table, tap sharply over the edge and the pieces will break clean, leaving the circle with no rough edges.

If the third step is omitted poor results will be obtained. The edges of the circular piece will not break clean and will have to be screened back or ground to remove rough edges. There will also be a greater amount of breakage.

Calibration Marking of Glass Apparatus

By ABRAHAM KRIEG, Pittsburgh, Penna.

IN the laboratory or shop it often is necessary to calibrate glass apparatus and to make a mark designating the calibrated level. The mark should have the following characteristics: (1) clear visibility; (2) permanent nature; (3) not affecting the structural strength of the apparatus so marked.

Such a mark may be easily made by scratching the glass with a triangular file at the place desired. This mark may extend for a short distance or entirely around the glass. The mark is then heated with a gas-oxygen flame until the glass is fused locally. The scratch mark, when annealed and cooled, has the white appearance found when the ends of two pieces of glass tubing which had been cut with a file are sealed together. A mark made in this manner has all the desired characteristics listed above.

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INSTRUMENTS ON THE MARCH

Mercury-198 Line as Length Standard

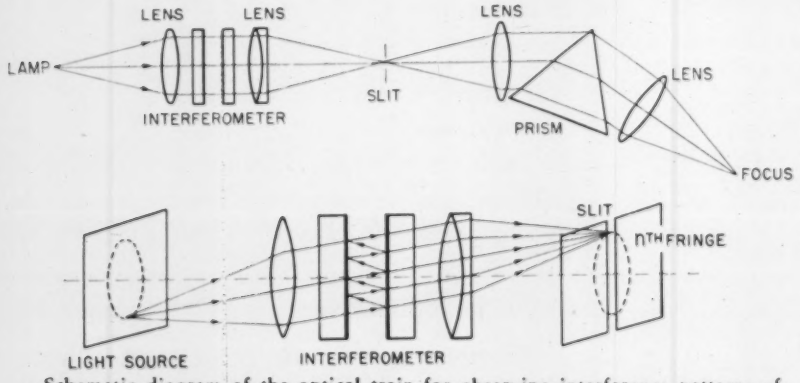
WASHINGTON, D. C.—According to Technical Report 1165 of the National Bureau of Standards, a new and better standard of length now exists in the wave-length of green radiation of mercury 198, an isotope transmuted from gold by neutron bombardment. In precision, reproducibility, and convenience, the new standard is superior to both the standard meter and the red line of cadmium, according to recent investigations by Dr. William F. Meggers of the NBS. Preliminary measurements by Dr. Meggers have shown an accuracy of one part in a hundred million of relative values and one part in a billion is theoretically possible.

Since 1889 the world's standard of length has been the "meter" distance between two lines on a platinum-iridium bar at the International Bureau of Weights and Measures in France. Fundamental measurements throughout all of science and industry are based on this standard, but it has several disadvantages. First, line standards are unsuitable in certain fields of measurement. Second, the "furrows" nature of lines ruled on surfaces limits the precision attainable. Third, the meter is not readily reproducible.

Primarily because the standard meter does not afford sufficient precision in some fields, the red line of cadmium has been universally used for many years for precise measurements. However, the cadmium standard also has serious disadvantages. First, there is a fine structure in the red radiation which makes the line "fuzzy" and thus limits the precision possible. Second, the cadmium standard requires excitation in a furnace which entails unwanted broadening of the spectral line because of relatively high temperature.

The green line of mercury-198 has none of the disadvantages of either the meter or the red line of cadmium. The normal human eye is far more sensitive to green than to red, an important consideration in visual adjustment of the interferometer with which lengths are measured and compared. All other characteristics desirable in a light wave standard—such as ability to be reproduced, absolute sharpness of the wave length, intensity of the spectral line, life and convenience of maintenance—are possessed to a greater extent by mercury 198.

Dr. William F. Meggers, Chief of the Spectroscopy Section, National Bureau of Standards, holds the electrodeless mercury lamp with its five milligrams of mercury-198 excited by high-frequency radio waves.



Schematic diagram of the optical train for observing interference patterns of spectral radiations emitted by the source lamp and collected by a lens to illuminate a Fabry-Perot interferometer. Light transmitted by the latter is focused by a corrected lens upon the slit of a prism spectrograph. The latter disperses the light into a spectrum and produces, at its focus, images of the interference patterns that are focused on the slit. Interferometer consists of two flat glass plates with adjacent parallel faces silvered or aluminized. Multiple reflections and partial transmissions at the plates produce interference patterns. In the lower diagram, light from one point of an extended light source is traced through the interferometer to its image on the slit. This image will be either light or dark accordingly as the retardation of reflected rays is an even or odd multiple of half wave-lengths. The symmetry of this condition about the optical axis forms circular fringes. The total number of waves between the interferometer planes is determined, without counting, from an approximate value, the relative values of their wave-lengths, and measurements of their interference patterns.

New Thermometric Standard

WASHINGTON, D. C.—A new thermometric standard utilizing the freezing point of benzoic acid as a fixed temperature has been developed and made available to industrial and other laboratories by the National Bureau of Standards. The acid, which is specially purified for the purpose, is contained in a cylindrical chamber, about 12" long and 2" in diameter, provided with a thermometer well. This device, known as a benzoic acid cell, affords a means of calibrating platinum resistance thermometers and thermocouples at a temperature near 100°C. more rapidly and conveniently and, under certain conditions, more accurately than is possible with the boiling point of water. The temperature provided by the cell is virtually the triple point of benzoic acid (122.362°C.).

Benzoic acid cells, developed by the NBS to provide a new thermometric standard. Each cell consists of a thermometer well (its extension visible at right) surrounded by a chamber containing benzoic acid, which is melted and then allowed to freeze gradually. An uncalibrated companion cell containing acid of lower purity is useful for practice in manipulation and for pre-warming the Dewar flask in which the certified cell is placed to retard freezing.

The boiling point of water is well established as a fixed point in thermometry not only for historical reasons

but also because the thermal properties of water and its ease of purification make it an almost ideal standard substance. The laborious barometric measurements required for accurate observations of the steam point have constituted the principal drawback to the use of this temperature in thermometer calibration. Recently, however, as the result of an investigation of the properties of benzoic acid by F. W. Schwab and Edward Wichers of the Bureau, it has been found possible to use the freezing temperature of benzoic acid for this purpose with a precision comparable to that of the steam point as observed in most standardizing laboratories.

To use the cell, it is heated in an oven until the acid has melted and reached a temperature a few degrees above its freezing point. The cell is then shaken until the liquid begins to freeze, forming a mush of fine crystals; thereupon the cell is put in a Dewar flask to retard the rate of freezing. The resistance thermometer (or thermocouple) to be calibrated is placed in the well, and observations of resistance (or emf.) are made for a period of one to two hours. After the first thirty minutes, the temperature of the cell is constant within 0.001°C. for an hour or longer and is reproduced in repeated "freezes" within a maximum range of 0.002°C.

The freezing temperature of each cell

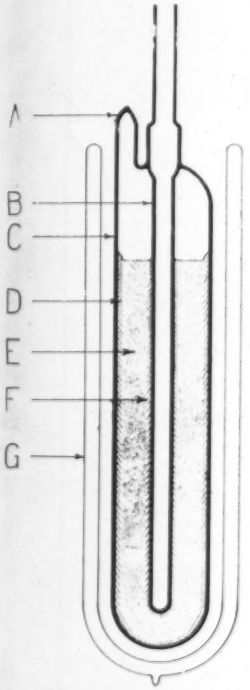


Diagram of new NBS benzoic acid fixed-point cell. The cell (C) is first warmed to melt the benzoic acid it contains, then cooled until a mass of crystals (E) appears throughout the liquid. At this point the cell is placed in Dewar flask (G) to retard further freezing. When the instrument to be calibrated is put in the thermometer well (B), the slight loss of heat to the instrument causes a thin layer of acid (F) to freeze on the outer wall of the well. The temperature of the thermometer is thus nearly the temperature of liquid-solid equilibrium for benzoic acid. As freezing gradually proceeds, a layer (D) of solid benzoic acid forms on the inner wall of the cell. The acid was initially transferred to the cell through the side tube (A), which was then sealed off.

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The Solution

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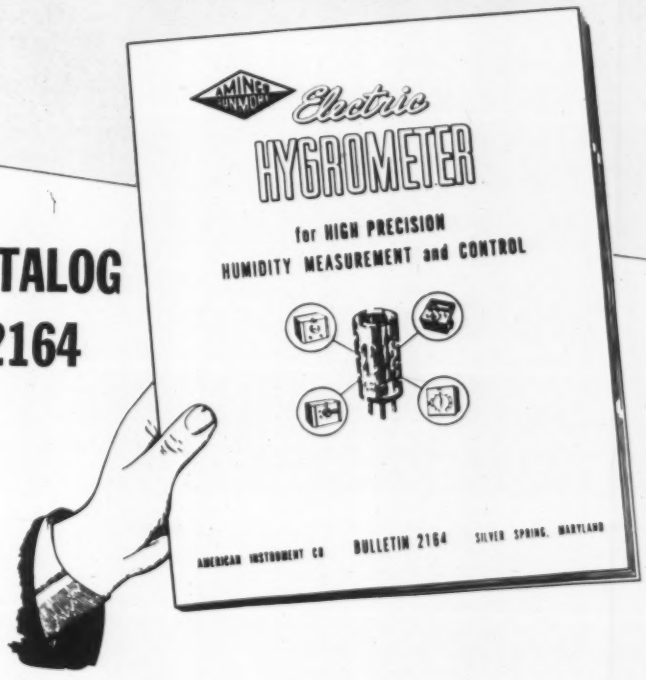
New 28-page bulletin describes complete line of Electric Hygrometer Equipment for precise measurement and control of relative humidity.



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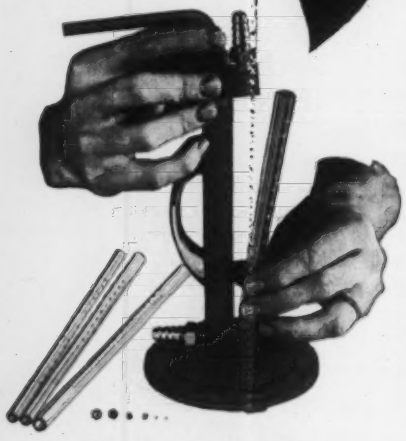

"C-Clamp" FLOWRATOR meter kit. The meter is provided with a convenient carrying handle, base plate and hose connectors.
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The new "C-Clamp" FLOWRATOR instrument kit consists of an extremely flexible combination of one meter, four metering tubes and six readily identified floats. The selection of proper tube and float combinations is simplified. The "C-Clamp" meter construction permits easy disassembly for quick metering tube changes. Capacities from 0.065 to 2200 cc/min. of water and 5.0 to 36,800 cc/min. of air are covered.

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issued by the Bureau is certified to an accuracy of ±0.003°C. However, this is an estimate of the uncertainty involved in fixing the temperature on the International Temperature Scale, and does not relate to the constancy with which the temperature is maintained in a given cell during the time necessary for observations or to the day-by-day reproducibility of the cell.

Certified cells may be obtained from the National Bureau of Standards for a fee of $100.00 each. An uncalibrated companion cell containing acid of lower purity is offered for $15.00; it is useful for practice in manipulation and for pre-warming of the Dewar flask. Cells are available with thermometer wells in three diameters, 8, 10, and 12 mm. The diameter that most nearly fits the instrument to be calibrated should be used.

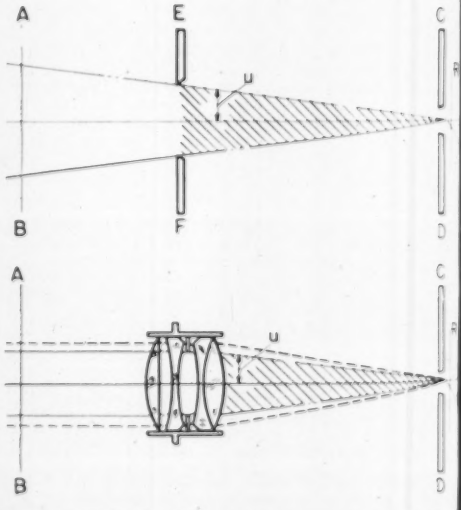
New Calibration System for Photographic Lenses

WASHINGTON, D.C.—According to Technical Report 1156 of the National Bureau of Standards, an improved system for calibrating the diaphragm openings of a photographic lens has been developed by Dr. Irvine C. Gardner of the NBS. This method of marking apertures, in contrast to the system that has been in use, takes into account the losses of light from absorption, reflection, and scattering within the lens. It thus permits a more precise and accurate control of the amount of light admitted to a photographic film during an exposure, with a corresponding increase in the uniformity and quality of results. Such a system of marking is particularly important in color photography because of the smaller latitude of color film.

The method of speed marking of lenses now in general use is based entirely upon the ratio of the equivalent focal length of the lens to the diameter of the aperture. This ratio—known as the *f*-number—gives no consideration to the great differences in the useful light transmitted by various lenses. Since introduction of reflection-reducing coatings, for a given *f*-number the light transmitted by two lenses may differ almost by a factor of two.

In the new method of calibration the marking "8," for example, does not correspond to the geometrically determined aperture ratio 1:8, but to an opening sufficiently large to permit the transmission of as much light as would be transmitted by a lens set at the aperture 1:8 if there were no losses. Such a system of apertures may be referred to as equivalent or compensated apertures. The markings are obtained by a relatively simple photometric procedure, in which the diaphragm of the lens to be calibrated is adjusted to transmit the same amount of light as a similarly placed opening of standard size. This standard opening corresponds to an ideal lens of a given aperture ratio, in which incident light is wholly transmitted. A complete calibration is obtained for a given lens by the use of a series of openings of graduated size corresponding to various aperture ratio values. The basic principles of the method are shown in the diagrams.

A standard designation for the new system of markings has not yet been agreed upon. Terms that have been suggested are *effective-f-number* and *t-number* (the *t* standing for transmission). After the effective-*f*-number 4 has been determined in this way, the plate EF is replaced by another plate with the opening changed in size. If the sine of the half-angle of the transmitted cone is now, say, 1/5.6, the setting for equal light intensity will correspond to an effective-*f*-number of 5.6.



In the upper diagram, AB represents a uniformly bright surface, CD a metal plate with a small hole at O, EF a second plate with a larger circular opening. The shaded area indicates the cone of light which proceeds from the screen AB through the two apertures and falls upon the photocell receiver (R). If we assume that the opening in EF is so chosen that the sine of the half angle of the shaded cone is 1/8, then, by the laws of photometry, as much light is transmitted to the photocell by the apertures in the two plates as would be transmitted if plate EF were removed and an ideal lens which transmits light completely were substituted with the aperture set at *f*-4. Now, if plate EF is replaced by an actual lens set at *f*-4 as in the lower diagram, the intensity of light provided by the shaded cone will decrease because of absorption, reflection, and scattering in the lens. However, the iris diaphragm of the lens can be adjusted to increase the cone of light, as indicated by the dash lines, until the photocell readings are the same for the opening of the upper diagram and the lens of the lower diagram. The setting of the lens then corresponds to an *effective-f-number* of 4. Other values of the effective-*f*-number may be determined by replacing the plate EF with other plates having openings of various sizes.

respond to 2.8 on the new scale. By continuing this procedure, as many values of the effective-*f*-number may be determined as are desired.

Except for the newer lens markings, this system requires no instrumental changes. Determining exposure time is no more complicated than at present.

This calibration procedure, based on the illumination at the center of the field only, insures equivalent exposures at the center of the image for lenses used at the same effective-*f*-numbers. Where vignetting must be taken into account, a similar procedure is followed, but the average light flux over the entire field is measured.

This system of lens calibration, involving only a matching of two photometer readings, is simple, direct, and accurate. As each calibration is essentially a substitution procedure in which the two values of brightness to be measured are of approximately the same value, errors arising from nonlinearity of response of the photometric apparatus are largely eliminated. The need for carefully calibrated filters is also avoided. Finally, the method provides a means by which different laboratories may arrive at the same calibration values without the interchange of physical standards, since apertures in metal plates—the only standards required—are readily constructed to the required sizes.

Diamonds Detect Radiation

WASHINGTON, D. C.—According to Technical Report 1139 of the National Bureau of Standards, radioactivity studies conducted by Dr. L. F. Curtiss of the NBS have shown that diamonds are highly sensitive to gamma rays and may be used to detect this radiation in the same way as a Geiger-Müller counter. It has been found that a diamond placed in a strong electric field initiates a sharp electrical pulse when a gamma photon is absorbed, so that pulse-rate measurement gives an indication of the intensity of the radiation. It is expected that a similar effect will be observed with beta radiation.

To use a diamond as a counter, it is clamped between two small brass electrodes maintained at a difference of potential of about 1000 volts. When a source of gamma radiation is brought within range of the diamond, there occur across the electrodes pulses of current which, after amplification, may be detected and counted on any suitable device. In the NBS apparatus, primary amplification is effected with minimum loss of original intensity through the use of a triode very close to the diamond in the circuit. The output from this tube is then applied to a two-stage amplifier, from which pulses of sufficient magnitude are obtained to operate the detecting instrument.

The diamond counter is a very "fast" counter, capable of indicating a much greater number of pulses per minute

When ordinary pressure gages are used on corrosive sour oil or gas, they last only 5 to 6 weeks. That's what one company* found. Then they tried Helicoid gages with K-Monel tubes.

After 55 weeks, they were removed for inspection. There were no signs of corrosion. The gages tested accurate and were put back in service.

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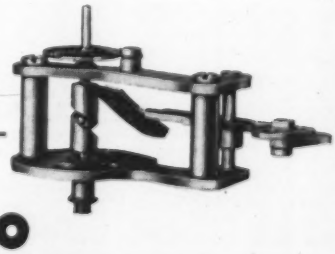
For better gage value for any kind of service, insist on Helicoid—the gage of enduring accuracy.

*Name on request



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A Gordon Furnace Atmosphere Indicator will watch that for you. It makes a continuous, thorough check of the furnace atmosphere, and as soon as it changes, the change is detected and indicated so that quick necessary adjustment can be made. It works on gas or oil-fired furnaces and in protective atmospheres on electric furnaces.

The Gordon Furnace Atmosphere Indicator works on the principle of the relative thermal conductivity of gases. It is so simple and easy to use that top results can be obtained with shop or non-technical personnel.

Where a continuous record of atmosphere readings is required, the indicator can be co-ordinated with a recorder.

You can't afford to be without this instrument any longer.

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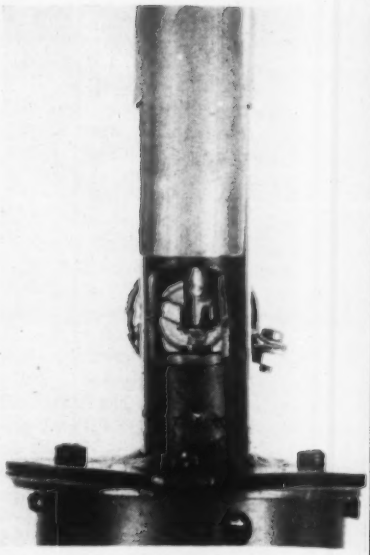
than is possible with the ordinary Geiger-Müller counter.

Similar principles have been utilized at the Bell Telephone Laboratories in experiments with alpha particles. Here, because of the poor penetration of this radiation, both electrodes were applied to the same crystal face, and the impinging particles were detected by means of the surface ionization they produced.

While gamma rays may produce photoelectrons in other crystalline substances such as sodium chloride, in most cases the crystal must be cooled to an extremely low temperature. The diamond is the only material so far investigated that performs satisfactorily at room temperature.

Industrial diamonds used as counters must be colorless and absolutely free of flaws; about one diamond in forty meets these specifications. Diamonds tested in the Bureau's laboratories have been found to have a sensitivity per unit volume equal to or greater than that of any man-made counter.

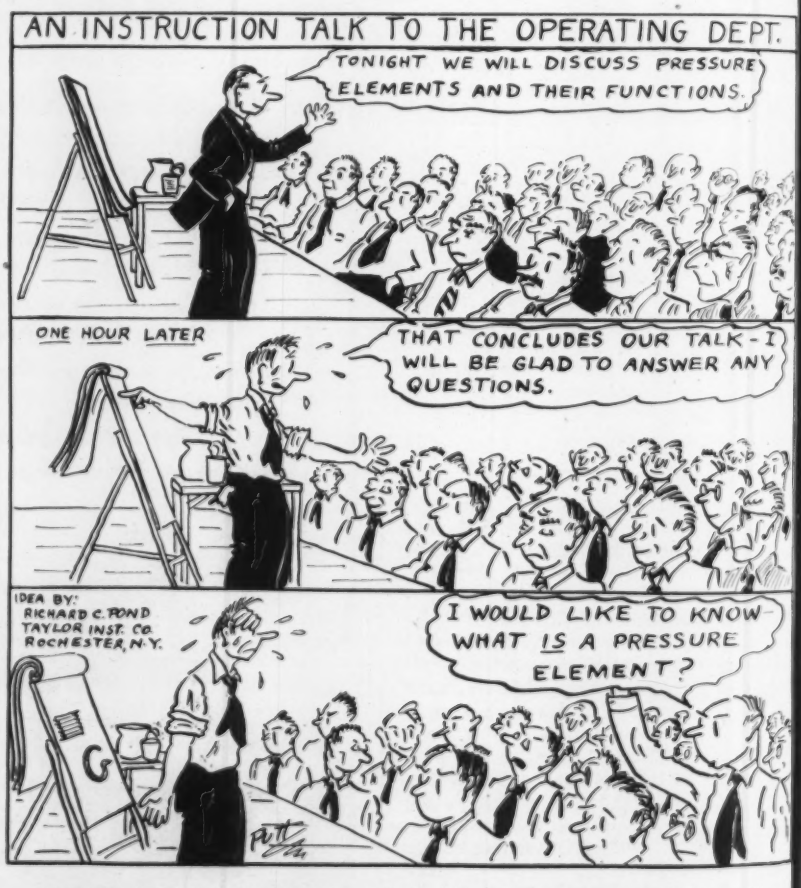
The conventional radiation counter lasts from three months to two years, depending upon how much it is used. A diamond counter, on the other hand, is practically indestructible. There is no appreciable cost difference between the diamond and an ordinary counter. However, one of the important advantages of the diamond counter, in addition to sensitivity and long life, is its small size, permitting use inside the human body or in small openings in industrial equipment.



The NBS diamond radiation counter.

WHEN A FELLER NEEDS CONTROL

By Phil Putnam


AN INSTRUCTION TALK TO THE OPERATING DEPT.
TONIGHT WE WILL DISCUSS PRESSURE ELEMENTS AND THEIR FUNCTIONS.
ONE HOUR LATER
THAT CONCLUDES OUR TALK - I WILL BE GLAD TO ANSWER ANY QUESTIONS.
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JOURNAL of the Instrument Society of America

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Vol. 3 — May 1948 — No. 5

Editorial

A LETTER FROM THE EDITOR

In October 1946, Vol. 1, No. 1, this space in the Journal started with these words, "It is with some misgivings that we take over our new task as Editor of the ISA Section of *Instruments*. It is our hope that you will bear with us until things get rolling a little more smoothly than they are for yours truly at this moment."

Those words seem to fit the present situation admirably and my fervent desire is that the current issue of the JOURNAL shall bear at least a slight resemblance to the preceding issues, so capably handled by R. R. Proctor. It turns out to be more difficult than I had expected to write again after 15 years but possibly some style of my own can be developed as time goes on.

No plans for a radical change in the JOURNAL are in the offing. Changes, if any, will be gradual and will come only after the new Publications Committee, headed by Ralph Batcher, has a chance to crystallize its ideas. In the meantime, I hope that all of the Section correspondents will be as helpful as they have been in the past. Until I learn that some change is required because of location, closing dates will remain the same.

There seems to have been a dearth of general, official and convention news this month but possibly this is simply a delay due to the editor's change of address and will be remedied before another issue. Please send all meeting reports, news items—anything you think may interest the majority of our members to

H. L. Hildenbrand
Box 35
Onarga, Illinois

Everything I can do to keep the JOURNAL interesting and valuable to all of you, I will do.

Last, but not least, thanks to Bob Proctor for his untiring efforts in getting out twenty issues of the Journal. May I be able to do as well.

—H. L. HILDENBRAND

General News

GRAY TELLS OF WORLD TRIP

Mr. Robert H .Gray, Esso Engineering Department, Standard Oil Development Company of New Jersey, has just completed a trip around the world. Excerpts from his letter follow: " . . . working at Palembang Sumatra, N. I., and in Australia, with stop-offs at Singapore, Honolulu, and other way stations. I'll be back in New Jersey soon and will be quite content to stay put for a while. The Japanese instruments we found in Sumatra were of such inferior materials as to be unusable in most cases. For example, the diaphragm rubber in control valves was crumbling although pre-war American diaphragms were still usable. The steel in flow meter manometers was also poor—after making up a pipe or bolt connection a half-dozen times the threads would be worn away. One of the few Jap items that was used, though only on a limited, temporary basis was thermowells. Analysis indicated these were made from 11½—13% chrome steel bar stock, sawing through a number of them proved good workmanship in keeping the bore concentric—but the Japs cut only 11 threads per inch instead of 11½ for 1-inch pipe threads! A temporary shortage of thermowells made it necessary to machine off the Jap threads, build up the metal with weld, and then cut new threads. These thermo-wells will all be replaced, of course, when new ones are delivered and are only being used on low temperature, low pressure application.

Among the 'atrocities' the Japs committed was the installation of 2 inch orifice flanges in a 1 inch pipe with 1 × 2 swages about 6 inches up and downstream! Wonder what sort of coefficient that meter would have? Apparently they never heard of maintenance—all the moving parts in recording potentiometers were so badly worn that they needed complete replacement—they probably had never been oiled or greased.

To pick out the most typical Jap performance I'll mention strip charts. They apparently had reproduced chart plates photographically, included 'Printed in U. S. A.' along with the rest, put on Japanese characters, and then put on, in English, 'Printed in Japan.' So where they were printed depended which side of the chart you examined."

At least one Section (Presque Isle) has asked him to describe his experiences and other sections might like to follow suit. Bob is at home at 1 Whippoorwill Way, Mountainside, New Jersey.

Official News

TO ALL SECTION SECRETARIES

The following additions should be made in the list of Section Secretaries, Directors and Journal Correspondents published in the Journal for December 1947:—
Rochester (New Section): Journal Correspondent—Chas. W. Covey, 311 Aldine St., Rochester 11, New York. Secretary—Ralph C. Schwarz, Jr.

Section News

CENTRAL INDIANA

At the April meeting of the Central Indiana Section, Mr. Walter Rufleth of the Bristol Company gave a very interesting talk on "Telemetering." His lecture was illustrated with slides which covered the various telemetering systems. A short film "Atomic Energy" produced by Britannica Films was also shown.—E. E. TAYLOR, *Corr.*

CHARLESTON

"Human Engineering for Instrumenticians" proved to be a very general discussion of hypertension in modern individuals. Remarks on the subject were addressed to the Charleston Section by Mr. H. H. Barnum, H. H. Barnum Company, vice president of I. S. A. The occasion was the April 5th meeting held in the Hideaway Room at the Hotel Kanawha. The hotel dining room was the scene of a well-attended dinner beforehand: visitors from out of town included Al Shafer and Sam Prince of the Pittsburgh section.—MARY K. ADAMS, *Corr.*

CHICAGO

The engineering, military, social, and medical aspects of ATOMIC ENERGY were all touched upon by Mr. R. J. Kryter of The Esterline-Angus Company, Inc., when he spoke before the Chicago Section on April 5th. Although each phase is a subject in itself, he had carefully selected pertinent facts of each, blended them together with a brief history of the development of nuclear physics, injected a warning of what could happen in the future, and delivered a well-prepared, thought provoking talk.

Mr. Kryter called attention to the fact that unfortunately most people think of the atomic bomb only in terms of a super-explosive. They fail to realize that the radio-active by-products of the explosion are death-dealing to the attacker as well as to the attacked, and that man now has at his disposal the means for destroying himself and civilization as we know it today.

In telling of the development and quantity production of radio-active materials, Mr. Kryter pointed out the important part played by instruments and controls. Without instruments and controls, the entire project would have been impossible because all work was carried on from remote points of safety for the personnel. Those who heard the talk were impressed, surprised, and perhaps somewhat astounded. If the information as given by him were conveyed to the general public, this nation might be shaken out of its lethargy and employ a firmer hand in its problem of dealing with ATOMIC ENERGY.

—DIAMOND S. DICKEY, *Corr.*

CUMBERLAND

The Cumberland Section held its regular monthly dinner meeting on Tuesday, March 23rd, at the Algonquin Hotel. The speaker of the evening was Mr. R. R. Webster, Research Engineer with the Jones and Laughlin Steel Corporation of Pittsburgh. Mr. Webster's talk was entitled "The Testing of Steel with Supersonics." His talk was very interesting to all since he started with a simple basic explanation of supersonics and then expanded the theory to apply to specific test purposes. Slides were used to good advantage for this purpose.

After his talk, a brisk discussion period was held which cleared up a large number of questionable points and left a few others open for further discussion.

—G. WILLIAM HARRISON, *Corr.*

DETROIT

At the March 16th meeting, Mr. W. O. Macgeorge and Mr. Winters, Automatic Temperature Control Company described and demonstrated the Atcotran. Such problems as the hysteresis of pressure gauges, weighing machines and other displacement type measuring devices were solved with this device.

The Atcotran can be depended upon for a sensitivity of 1 part in 6000 and an accuracy of ¼%. It requires as little as 45 microwatts of A power while controlling the amplifier that, in turn, supplies the indicating, recording or controlling instrument. Mr. Macgeorge had a roomful of equipment to demonstrate the actual operation of the Atcotran. He plugged various pickups into the circuit of a gargantuan indicator four feet square, showing pressure, weight and other variables on the same scale. He had the scale showing full travel for 0.8 inches of water and then for 1,000 lbs./in.^{2} hydraulic pressure. By shifting the circuits he connected the same elements to a recorder and then to a new projection indicator provided with three 72-inch scales. Flicking a

Siena Student Section of the Eastern New York Section

Reading from left to right, the third man is William Howland, Treasurer; fourth is William Cooley, Secretary; twelfth is Charles Poskanzer, President and last is Father Cronan Mullen, faculty adviser and head of the Science Department of Siena College.

THE FIRST STUDENT CHAPTER

A Student Subsection has been organized at Siena College and is under the guidance of the Student Affairs Committee of the Eastern New York Section, with Nelson Gildersleeve as chairman. The student group was organized in December, 1947 with Father Cronan Mullen, head of the Science Department at Siena College, as Faculty adviser. Before entering the priesthood, Father Mullen was an engineer with the Brown Instrument Co., Philadelphia.

At its annual meeting, the Eastern New York Section granted three student memberships in the ISA as a gift and these by chance were drawn by the three student officers. Many of the students attend the regular Section Meetings as well as their own subsection meetings. The Section is arranging a program of tours and lectures for the student group which, though having instrumentation emphasis, will be very broad in their scientific and engineering scope.

We welcome this Student group and hope that more Sections will take similar groups under their wing.

---

switch selected a scale graduated uniformly, another graduated logarithmically and a third that was divided by a sales message for Atcotrans.

—W. E. WILSON, *Corr.*

KANSAS CITY

On March 30th, the Kansas City Section met at "The Crossroads." Twenty-seven members and seventeen visitors were present. Gordon H. Burke of Burke Engineering Company, presented the second of a series of basic lectures on "Air Control." This lecture dealt with the function of automatic reset in air-operated controllers. W. H. Pugsley, Vice-President, in charge of Research of the Hays Corporation, Michigan City, Indiana, presented a lecture entitled "Electronic Type Recording Instruments for Oxygen, Carbon Dioxide, Temperature and Pressure." Mr. Pugsley's lecture was illustrated with lantern slides.

The lecture started with a note on the fundamental principles involved in the electronic tube for amplifying purposes, and then described how this tube operates in analyzing for oxygen and other acid gases. Among other items discussed and illustrated, were strain-gage type pressure transmitters, and tachometer transmitters.

Three new members turned in their applications and checks after the meeting.

—W. A. REICHOW, *Corr.*

LOUISVILLE

The March 30 meeting of the Louisville Section was held in the auditorium of the Speed School of the University of Louisville. Mr. George Leupold of Sylphon Bellows presented a film on "The Manufacture of Bellows." The speaker had complete command of his subject and a very lively delivery which made the program amusing and informative. —PAUL B. SMITH, *Sec'y.*

OAK RIDGE

The 24th meeting of the Oak Ridge section was held at Grove Recreation Hall, April 7th. Committee reports were heard and a new constitution group was appointed, headed by A. H. Fowler. Following the business portion of the meeting the evening was given over to Mr. Isenhour of the program committee who introduced the "speakers" of the evening, Mr. J. F. Schock and Mr. G. L. Broomell of the Leeds and Northrup Co. Their subject—"The Development of the Speedomax 'G' Recorder." Mr. Schock gave the history and general development of the unit. Mr. Broomell, with the aid of slides, presented the technical part. A general question and answer session concluded the evening.

—J. O. ALEXANDER, *Sec'y.*

PHILADELPHIA

On Wednesday, March 17, the Philadelphia Section met at the Penn Sheraton Hotel. The meeting was called by President Garner Parr, who turned the floor over to Messrs. Lyman H. Allen, Jr. of the American Viscose Corporation and Robert L. Hurley, Jr., of the E. I. duPont de Nemours & Company, Inc. Messrs. Allen and Hurley proceeded with a most interesting discussion on the subject of "Terminology in Instrumentation." Mr. Hurley built up the instrumentation on a process control diagram step by step. After the process was completely instrumented, Mr. Allen took up the terminology discussion from the standpoint of its relation to the actual instruments rather than to the process. From a number of charts, he showed the derivation of the various terms and their interpretation in actual instrument components.

The entire tone of the meeting was such as to impress upon all the need to follow a standard terminology such as has been presented under "Automatic Control Terms" in the I. S. A. Handbook and Recommended Practices Section. Several announcements were made following the more formal part of the meeting, one of these being the election of John Johnston, Jr., E. I. duPont de Nemours & Co., as a member of the National Board of Directors.

Tex Newcomb attended the meeting in a wheelchair, this being his first appearance at one of the meetings since his plane crash early last fall.

—JOHN S. KOCH, *Corr.*

RICHLAND

March has found the I. S. A. Richland Section quite active indeed. One might say that we are taking full advantage of our strategic location with respect to various instrument company representatives who seem to have quite an interest in our desert scenery at the present time.

Mr. Stratford B. Biddle, Jr., Field Engineer of the Leeds and Northrup Company, San Francisco Branch, was our speaker for the evening of March 3 at a special interim meeting in the American Legion Hall. His subject was "Improvements in Micromax Instruments." He traced the history of potentiometer-type instruments from their origin by Poggendorf to the refined instruments of today. Mr. Biddle then compared the mechanically operated Micromax with the electronically operated Speedomax also made by Leeds and Northrup. Much interest was shown and numerous questions asked during the discussion of Micromax servicing problems. Eighty-one members and guests attended.

The sixth regular meeting held March 10th opened by President E. S. Day, Jr. in the Columbia High School lunch room. Guests at this meeting included Mr. F. H. Trapnell, Vice-President of the Instrument Society of America, Mr. F. B. Quecly of Selah, Wn., Mr. L. W. Williams of Portland, Oregon and Mr. A. R. Soffel of the Kellex Construction Corporation. Mr. Lawrence Parsegian was introduced as the principal speaker of the evening. Mr. Parsegian, formerly with the Design Division of C. J. Tagliabue Co., is at present associated with the Kellex Construction Corporation.

Speaking on the broad subject of "Temperature Measurement," Mr. Parsegian covered the separate items of liquid-in-glass thermometers, resistance thermometers, thermo-electric and optical pyrometry. The address was very capably presented and well received by the seventy-three members and guests who signed the roll sheet. Mr. Sidney Irving of the Instrument Department, Hanford Works, then presented some of the problems which have confused him in his work on the many balances which he maintains. His discussion of micro-balances aroused particular interest of several members. The program was concluded with the showing of two General Electric sound movies entitled "Jet Propulsion" and "Central Station Fire Control."

At a second interim meeting March 31, Mr. L. W. Williams will lecture and give a demonstration on the Brown "Electronik" recorder. A recent poll indicated that 80% of the group feel that we should have dinner meetings quarterly and it is hoped that the first dinner can be planned for the April 14 meeting.

—JOHN K. FLICKINGER, *Corr.*

ROCHESTER

The third meeting of the newly organized Rochester Section was held Tuesday, March 23 at 8:00 P.M. in the Physics Building on River Campus of the University of Rochester, Rochester, New York. The speaker of the evening was Dr. Ralph C. Platt of the Physics Department of the University of Rochester. Dr. Platt gave a very interesting talk from the standpoint of the average instrument man on the subject of "Instruments Used in Nuclear Physics." The speaker received his B.A. degree in Physics from the University of Rochester and his Ph.D. degree from Cornell University. He served on the Radiation Laboratory Staff of Massachusetts Institute of Technology during the war.

Dr. Platt compared the study of the nucleus with the study of a fine watch by the method of hitting the watch with a hammer and observing the flying pieces. The nucleus is bombarded with electrons, neutrons and protons and the particles knocked away are studied from photographs of cloud chambers and other devices.

There are two general groups of instruments used in nuclear studies, source of high energy particles and detectors to study reactions of bombardments. The speaker discussed the electrostatic generator, Sloan-Lawrence linear accelerator tube, and the cyclotron as methods of securing high energy particles for bombarding neuclei. Particles with energies ranging from 1 million to 250 million electron volts can be obtained with these units. The general operation and characteristics of the three energy sources were discussed with many questions being asked concerning the cyclotron. The new cyclotron at the University of Rochester is now under construction and will provide particles with 250 million electron volts energy when completed.

Cosmic radiations were discussed as one method of nuclear bombardment. However, they are slow and difficult to control. The first instrument discussed for detecting high-energy particles was the Geiger-Miller tube. The cloud chamber method was then discussed. This method seems to be the most accurate and commonly used. It consists of a space filled with supersaturated gas which will show the trail of a charged particle moving through it.

The analysis of photographic plates exposed to radiations was explained as another method of detection. Several very interesting slides of photographs of photo-

(Continued on page 479)

Design and Applications of a New Metals Comparator

By D. E. BOVEY, General Engineering and Consulting Laboratory, General Electric Company

DURING the last decade, especially during the war years, non-destructive inspection and comparison of metal parts and stock became increasingly important. A variety of equipments were brought out to accomplish these purposes by measuring electrical or magnetic quantities which vary in accordance with variations in the physical or chemical properties of metals. Recently, an improved design of metals comparator has been developed in the General Engineering and Consulting Laboratory of the General Electric Company.

Its development was the sequel to the building of a comparator in one of the Company's plants during the war for conducting magnetic studies of various ferrous metals. Because of the success of this first instrument, several more were built for use in other departments. Following the war, it was felt that need existed for a relatively inexpensive comparator combining the advantages of several of those currently available. The Metals Comparator shown in Fig. 1 was developed to meet this need. It is relatively small, inexpensive, and so simple to operate that it can be used for inspection in a stock room or on a production line.

The device furnishes a convenient and non-destructive rapid method of determining whether or not a particular piece of metal is identical with a standard specimen in composition and and characteristics. This is done by inserting the piece in the center of a solenoid forming one leg of a balanced circuit, the other leg of which is a variable resistance. Balance is first obtained with a standard specimen inside the solenoid. If the piece tested is identical, balance will again be obtained. If it is not identical with the standard specimen, the impedance of the test coil is not the same and the circuit is unbalanced, a condition which can be read on a microammeter.

The instrument has been used to differentiate between annealed and unannealed steel bars. It has also been used to sort finished metal parts, including plated parts, on the basis of composition or heat treatment. Ferrous metals can be sorted on the basis of average hardness. Material or parts to be tested need not be wiped, cleaned or otherwise specially prepared for testing.

Specimens can be tested as rapidly as they can be inserted in the test coil and removed after the instrument pointer has come to rest. Tolerances can be established so a specimen is accepted or rejected on the basis of whether the pointer reading is within a specified number of scale divisions from the center.

*Presented at the Second Annual Conference of the Instrument Society of America, Stevens Hotel, Chicago, Ill., Sept. 8-12, 1947.

NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.

The Author

Mr. Bovey received his B. S. in E. E. in 1930, from Iowa State College. He then had a variety of engineering assignments until he became affiliated in 1940 with the Woodward Governor Company, where he designed various electrical components and developed electronic mensuring devices. In 1945, he joined the General Electric Company, where he is now located in the AC Measurements Section of the General Engineering and Consulting Laboratory.

Description

The comparator is mounted in a steel cabinet about 11 in. by 17 in. by 22 in. and weighs a little less than sixty pounds. Test coils range in size from ¼ inch to 3 inches in diameter.

The equipment is designed for operation from the 60 cycle commercial supply at any voltage from 100 to 130 volts. Because of the small size of the apparatus and the low power requirements, the instrument can be used in almost any convenient location.

Principles of Operation

It is well known that there is a correlation between the chemical and physical properties of metals and their electrical and magnetic properties. It is also well known that induced currents in metals located in varying magnetic fields depend upon the frequencies of the fields, and the apparent permeabilities of magnetic materials also vary with frequency, but at a different rate.

Reference to the accompanying simplified schematic drawing, Fig. 2, will aid in understanding how these two basic facts are used in the Metals Comparator. As shown in the diagram, the test coil is connected in series with a group of balancing resistors. The point of common connection is grounded, and the output of a variable frequency oscillator is supplied to the test coil in series with the balancing resistor group. Then the resistance of the balancing resistor group is the same as the impedance of the test coil at the particular frequency being used, the magnitude of the alternating voltage across the balancing resistor group is equal to the magnitude of the voltage across the test coil (although these voltages are not in phase with each other), and a condition of balance of the voltage magnitudes exists.

If balance is secured with a standard specimen in the test coil, and then with all controls unchanged the standard specimen is replaced by another having different electrical or magnetic properties, the impedance of the test coil is changed and balance no longer exists. By providing a suitable means of indicating the condition of balance, this arrangement can be used effectively to compare metals because of the correlation between the physical and chemical properties of metals and their electrical and magnetic properties.

In general, the impedance of the test coil is increased by an increase of either the permeability or the resistivity of the specimen inserted in it. It is, therefore, possible to find two unlike specimens which will both produce balance at some particular frequency and at the same balance setting, and will thus test alike at that particular frequency. For example, if at 250 cycles one sample had higher permeability but lower resistivity than the other, and the differences were just sufficient, both would

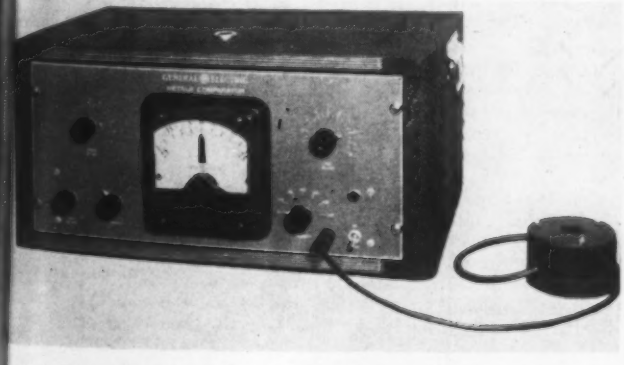

Fig. 1. The General Electric Metals Comparator.

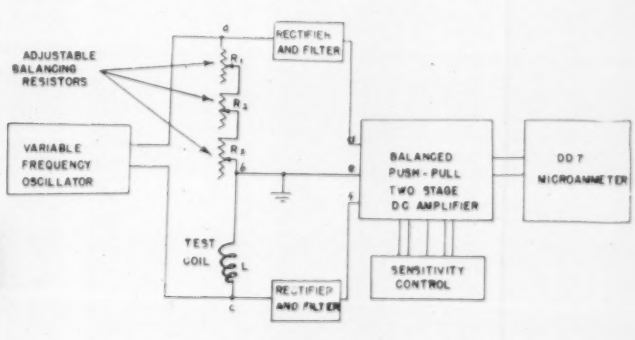

Fig. 2. Simplified Schematic Diagram.

Fig. 3. Identifying Steel Stock in the Stock Room.

and sensitivity, the alternating voltages across the test coil and balancing resistors are separately rectified and filtered, and the direct voltages resulting are applied in opposition to the input of a balanced, two-stage, push-pull, direct coupled, D.C. amplifier of very good stability. The output of the amplifier is supplied to a General Electric Type DD-7 microammeter. Four sensitivities are secured by controlling the overall gain of the D.C. amplifier in steps. The maximum sensitivity available is such that a reliable indication is secured when the replacement of one sample by a dissimilar one in a suitable test coil causes a change in the impedance of the test coil of less than 0.5%.

The connections of the indicating instrument are so arranged that a deflection of the pointer to the right of the zero indicates that the impedance of the test coil has been increased, and to the left that it has been decreased.

Applications

Among the practical problems that have been solved successfully by the Metals Comparator is that of identification of steel bars in storage. A number of 1 in. diameter, cold drawn, steel bars (AISI C1020) in a stock room were thoroughly mixed after each had been stamped with an identifying number. Part of them had been non-scale annealed and the rest had not. The comparator was placed near the stock pile as shown in Fig. 3. The test coil was then slipped over the end of one of the bars of the unannealed stock. A test frequency of 50 cycles was used. All of the unannealed bars produced readings in the range of plus three to minus two, while all of the annealed bars of the same material produced readings in the range of plus eight to plus thirteen as shown in Table I. In making these tests, the coil was slipped over the end of each bar a distance of about two feet to avoid end effects.

A few bars of AISI C1010, AISI B1111, Type 416 free-machining steel, and Ingot iron were also compared

test alike, although they were different. However, because the permeability and loss effects of metals vary at different rates with respect to frequency, they would not test alike at some other frequency, such as 500 cycles. The comparator design takes advantage of this by having an oscillator which supplies test frequencies of 50, 250, 500, 1000, 2500, 4000 and 10,000 cycles per second. Since in most applications, samples of the different parts to be identified are available, it is a simple matter to try two or three different test frequencies to determine which one gives the best identification.

A second and equally important reason for providing a range of test frequencies is the necessity for testing both magnetic and non-magnetic metals. Since the permeabilities of magnetic materials range from near unity to 1,000,000, the effect of introducing a piece of magnetic material in the field of a coil having an air core is usually appreciable, and a noticeable change in impedance of the test coil at frequencies as low as 50 cycles per second can readily be obtained. Samples having different physical properties usually have quite different permeabilities. These two facts make the use of low frequencies practical for testing magnetic materials.

However, since the permeabilities of non-magnetic materials are approximately unity, the effects of introducing non-magnetic samples in the test coil are produced only as a result of the induced currents in the samples. These currents are small in magnitude at low frequencies, so the testing of non-magnetic materials is not practical at such frequencies. Consequently, the higher test frequencies of 1000, 2500, 4000, ano 10,000 cycles per second have been provided for testing non-magnetic metals.

The availability of a wide range of test frequencies results in increased versatility of the comparator. The magnetic fluxes produced at low frequencies penetrate the specimens, and consequently identification is based on the materials of the cores of the specimens as well as the surfaces. The fluxes produced at high frequencies predominate in the surfaces of the specimens, so identification is based on the surface materials when the higher test frequencies are used. This phenomenon permits the testing of samples that could not otherwise be tested, such as case-hardened parts.

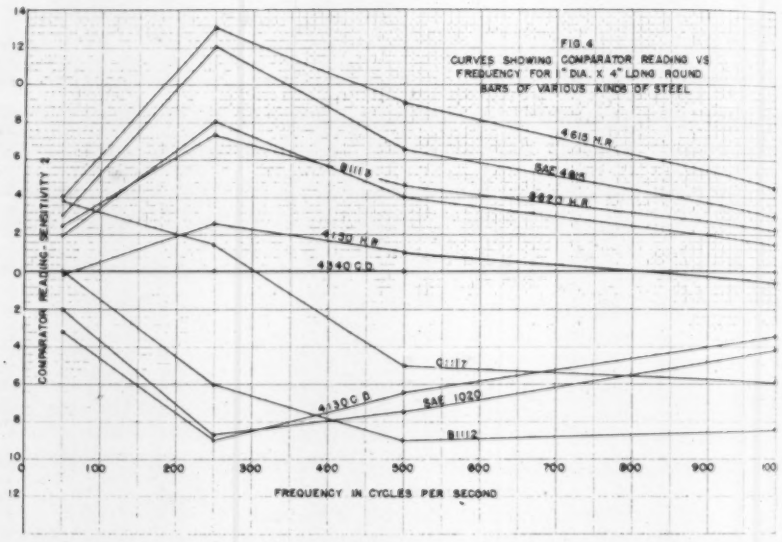

Fig. 4.

Experience indicates that the most suitable method of showing the condition of balance of the comparator to the average non-technically trained worker who might be assigned to its operation is to indicate it with the pointer on the scale of a large, easily read instrument. Such balance indications permit the assigning of specific tolerances to the amount of unbalance that can be permitted for various applications, and eliminate the necessity for the operator to interpret patterns on an oscilloscope screen. They also reduce operator fatigue and eye strain. For the sake of simplicity, reliability,

with the AISI C1020 bars, with the results shown in Table II. From this table, it appears that the bars of B1111 and Ingot iron tested approximately alike, though they were both different from the C1020 with which they were compared. Consequently, specimens of each were compared at a test frequency of 500 cycles and the separation was definite.

Where a mixed lot of bar is known to consist of only two or three different types, it is a simple job to select a few of each type and try testing at several different frequencies and sensitivities to see which gives the best results. If the mixture contains more than two or three different types, a few of each type should be tested at each of several different frequencies and the data thus secured plotted in the form of curves as shown in Fig. 4. In this instance, cold drawn 4340 steel was used as a standard, and a sample of each of nine other kinds were compared with it at 50, 250, 500, and 1000 cycles. From these curves, it can be seen that at some one of the frequency settings, each kind can be separated from the others. In Fig. 5 are shown data secured in sorting a group of 44 relay armatures, most of which had been previously rejected in production because of faulty relay operation. Six acceptable ones were included in the lot. The dotted lines are drawn to include all points plotted for all samples included in each group, in order to show the amount of variation between samples of given groups. After these data were secured, the groups were identified by chemical analysis to check the results. Samples 1 to 12 inclusive were annealed Nicaloi, but were from three different batches. Only samples 5 to 10 inclusive were acceptable. Sample 36, 37, 38 and 42 were unannealed Nicaloi. Samples 14 to 18 were stainless steel. The remainder were various types of cold rolled, silicon and chrome steels, but the identifications were somewhat uncertain. It will be seen from these curves that if a test frequency of 500 cycles and a sensitivity setting No. 3 were to be used, all acceptable samples would read within the range from plus three to minus three, and all other samples would read offscale in one direction or the other.

In Fig. 6 is shown a curve plotted from data secured in tests of case hardened materials. A number of pieces of drill rod of 3/8 in. diameter and 4 in. long were uniformly case hardened to various depths by induction heating, so that the internal portions of the bar would not be affected. The curve indicates that under favorable conditions, it would be possible to use the comparator in a production inspection line to isolate any pieces that differed from a standard sample in depth of case hardening by more than a prescribed small tolerance. If case hardening were done by older methods, in which the pieces are subjected to heat treatments in which carbon is added to the outer surfaces of the parts, comparisons cannot be as successfully made by this in-

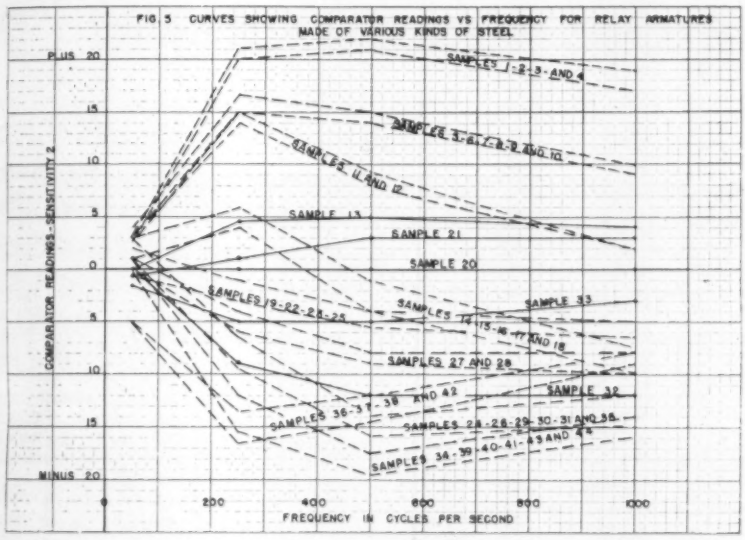

Fig. 5

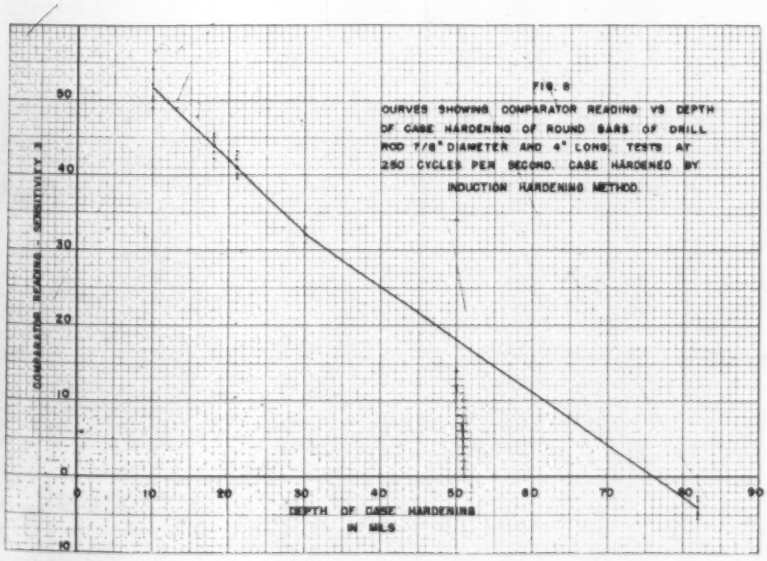

Fig. 6

TABLE I

Data secured in sorting AISI C1020 bars in steel stock room. The test frequency was 50 cycles per second, and the No. 2 sensitivity was used.

Sample Number	Description of Steel	Comparator Reading
198	AISI C1020	+2.0
113	Cold Drawn	+0.5
108		+2.0
186		−1.0
125		−1.0
194		−1.0
195		0
184		0
104		0
179		+1.0
158		+3.0
178		−2.0
182		−2.0
180		−1.0
196		−1.0
181		+1.0
199		+1.0
183		0
105		+1.0
161		0
215	AISI C1020	+9.0
200	Cold Drawn	+9.0
218	non-scale annealed	+10.0
213		+13.0
212		+8.5
210		+9.5
206		+9.0
219		+9.0
201		+9.0
204		+11.5
209		+9.5
207		+13.0
202		+9.0
217		+9.0
216		+8.0
221		+9.0
208		+8.0
205		+9.0
214		+10.0

TABLE II

Data secured in steel stock room to show differentiation between indications secured with AISI C1020 cold drawn bars, and bars of other types of steel. Test frequency—50 cycles per second.

Description of Steel	Comparator Reading
AISI C1020 Cold Drawn	0 to +2 (Balance)
AISI C1020 Cold Drawn and non-scale annealed	+9
AISI C1020	+25+ (off scale)
Steel bar type 416 free mach. Hot rolled-annealed centerless gnd.	+25+ (off scale)
AISI B1111 screw stock	+17
Ingot Iron Cold Drawn	+17

Test Frequency 50 c.p.s.

strument. The reason is that the internal portions are usually affected by the heat treatment, and the same amount of carbon may not be added to each piece, so that there are several variables, instead of only the one of case depth.

Some tests have been conducted in connection with the determination of plating thickness. It was found that there was identification between thick and thin plating of the same metallic material on both magnetic and non-magnetic base materials, and that there was a definite relationship between the thickness of nickel plating on brass and the comparator reading.

Data have been secured that indicate that the comparator can be used to sort steel parts on the basis of their Rockwell hardnesses. The principal difficulty encountered in correlating hardness with magnetic properties is that of determining the actual hardness of the standard samples with which unknown parts can be compared. For example, several hex nuts submitted by an automotive manufacturer were tested on a standard Rockwell tester ,and the variations in hardness as measured at two points on each of the six faces of a single nut ranged from a Rockwell C reading of 27 to 34. With such conditions the comparator will indicate only whether the average hardness of the nut being tested is more or less than the average hardness of the standard nut with which it is compared.

Several of the practical problems that have been solved recently by the use of the Metals Comparator will further illustrate its application. In one instance, several bars from a stock of several hundred were issued to the machine shop. The entire stock was thought to be AISI 416 free-machining, stainless steel. However, a complaint was received from the machine shop that some of the bars had poor machineability and tools were being broken. It was, therefore, necessary to sort the entire stock. The Metals Comparator was tried, and since there were both 7/16 inch diameter and 9/16 inch diameter bars in the stock to be sorted, each size was tested separately. The 7/16 inch diameter stock was separated into four groups, two of which were free machining and two of which were not. The 9/16 inch diameter stock was separated into three groups, two of which were free machining and one of which was not. A test frequency of 500 cycles was used and a sensitivity setting of number 2. The two groups that tested nearest alike, differed by about ten divisions, or 20% of full scale

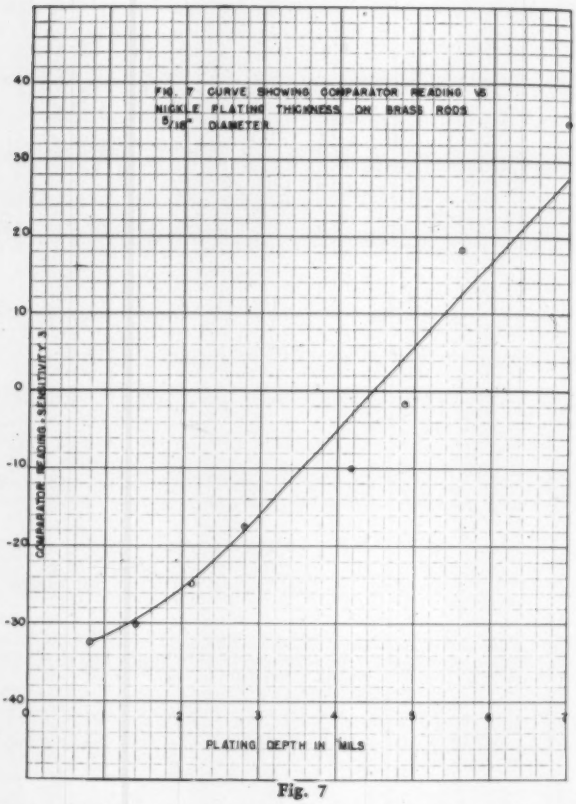

Fig. 7

on the indicating instrument. This difference could have been increased by using a higher sensitivity.

Although the problem was solved by the sorting described, it was considered desirable to secure some more detailed data for future reference. Consequently, a sample from each group sorted was chemically analyzed. The results showed that in addition to the AISI 416 stock, bars of AISI 302 and AISI 440C were both present. Two different groups of each of the 416 and 440C were found. This was probably due to the fact that there were both annealed and unannealed bars of each of the two types present.

In another instance several samples of bar stocks were submitted for tests. It was desired by the manufacturer who submitted these samples to test bars of stock before using them, to check their identification. The Metals Comparator was tried, and it was found possible to sort all the samples tested. When another manufacturer wished to check finished parts to determine whether or not they had been heat treated, the test was easily made with the Metals Comparator.

It was found possible in another application to separate samples of a copper alloy having only slightly differen percentages of iron in their composi tions. The iron content varied fro 0.006 to 0.021 per cent.

The Metals Comparator was als found to be effective in testing the ca bon content of sheets of steel made fo transformer cores. In this applicatio the only quantity that varied by a appreciable amount was the carbo content, and it was found possible t sort on this basis. For many years fixed-frequency (60 cycles) magneti comparator has been used in inspectin ferrous parts for hardness, compositi or heat treatment. Tests have bee made on bullet cores, springs, compas shafts, aircraft landing gear, screw knife blades, relay armatures, drill saw blades, mixed plates, mixed bar connecting rods, etc. The extension fixed frequency to variable frequenc and the increase in sensitivity foun in the Metals Comparator extends th usefulness into the field of productio and fabrication of all non-magneti metals and means greater reliability i the separation of magnetic materials Thus, a quality control tool is bein provided for all metals producers an fabricators.

Section News

(Continued from page 466)

graphic plates exposed to cosmic radiations at high levels above the earth were shown and explained.

A short business meeting followed the lecture. Several important questions regarding membership were discussed. The publicity committee was created and members appointed. The society now has approximately sixty members and our new organization is functioning smoothly to make this one of the best Sections in the country. Newly installed officers are:

G. F. Akins, Eastman Kodak Co., Chairman; I. G. McChesney, Vice-Chairman; Ralph C. Schwarz, Jr., Secretary; Ronald Reamer, Treasurer; N. B. Nichols, Chairman Program Committee; G. C. Britton, Chairman Membership Committee; Chas. W. Covey, Chairman Publicity Committee and Journal Correspondent, 311 Aldine Street, Rochester 11, New York.

—CHAS. W. COVEY, *Corr.*

WASHINGTON

Mr. H. M. Dimond, General Engineering and Consulting Laboratory, General Electric Company, Schenectady, New York, talked on "New Techniques of Time, Speed and Frequency Measurements" before the Washington Section on Tuesday, March 23, 1948.

Covered in his talk were a variety of instruments, including the General Electric Precision Tachometer and Time Interval Meter and Electronic Counter, for making these measurements. Applications for the various instruments high lighted the talk, illustrated by projection slides.

—R. E. HADADY, *Corr.*

I.S.A. EMPLOYMENT SERVICE

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DEVELOPMENT AND DESIGN ENGINEER to take charge of development and design department of instrument company manufacturing a wide diversity of testing instruments and scientific apparatus. Leadership and experience important. Write giving complete background as to education and experience, age, salary expected. Location Middle Atlantic States. All correspondence confidential. Box 13

(Continued on page 472)

CALENDAR OF EVENTS

Speaker	Date of Next Meeting	Type	Place	Section	Subject
tral Indiana	5/4/48	MX	Central Library	Mr. Mahlmeiser, Sheffield Co.	Modern Concept of Gaging Practice
rleston	5/3/48	DX8	Kanawha Hotel	Dr. D. J. Bergman, Universal Oil Products Co.	Instrumentation of Fluid Catalyst Cracking Units
cago	5/7/48	DX	Furniture Club of America	Installation of new officers	Social Program, Dancing and Entertainment. Ladies night.
tern New York	6/1/48		Siena College	Dr. James E. Foote, Diamond Match Co.	Instrumentation at the Ogdensburg Mill.
sas City	5/25/48	DX6	Crossroads Cafe	Clayton H. Barnard, Bailey Meter Co.	Electric Instruments and Controls for the Process Industries.
sville	5/25/48	M8	Seagram's Calvert Hall	C. B. Moore, Moore Product Co.	The Solution of Instrumentation Problems by the Pneumatic Hull Balance Method
Jersey	5/14/48	D68	Essex Hotel, Newark	J. J. Heigel, C. W. Skarstrom	Spectrographic Methods of Gas Analysis
ara Frontier	5/24/48	M8	N. Y. State Inst. Appl. Arts & Sci.	Business meeting	Election of Officers
idge	5/5/48	D78	Grove Recreation Hall	Bruce A. Irwin, Hammel Dahl Co.	Diaphragm Control Valves
delphia	5/19/48	DX8	Penn Sheraton Hotel	Ward W. O'Connor, Lummus Co.	"Presenting the Contractor's Viewpoint on Plant Instrumentation."
Louis	5/5/48	DX8	Engineer's Club	Dr. Frank W. Bubb, Washington Univer.	New Measuring and Computing Systems.
th Bend	5/13/48	DX8		Henry Schmidt, Brown Instrument Co.	The Low Range & Radiamatic
thern Michigan	5/12/48	DXX	Chicken Charlies, Kalamozoo	R. R. Proctor, Pure Oil Co.	The Electronic Road Test Panel
sa	6/7/48	MX			Election of Officers for 1948-49
in Cities	5/26/48	DXX	Coffman Mem. Union, Univ. of Minn.	Movies	"Atomic Energy," "Bikini Island Tests." "Operation Crossroads."
yne County	5/17/48	DX8	Presbyterian Church Hall, Wyandotte	T. Cawthorne, West. Elec. Instrument Co.	Electrical Instruments and New Developments

Legend: Meeting only, no dinner—M7, MX or M8 (7 pm, 7:30 pm or 8 pm respectively) Dinner meeting—first symbol D; second symbol time of ner (6 for 6 pm, X for 6:30 pm, 7 for 7 pm); third symbol time of meeting (7 for 7 pm, X for 7:30 pm, 8 for 8 pm).

Concentrated Course on Industrial Instrumentation for College Professors

Although most engineering colleges are terested in teaching industrial instrumenion for the reason that their graduates ll immediately come into contact with inuments for indicating, recording and conolling the variables of pressure, temperre, flow, and many other variables enuntered in industrial processes, relatively of them are now offering such a rse, particularly a course involving labotory work.

The Chemical Engineering Department Worcester Polytechnic Institute has been ked by the Sub-Committee on Industrial strumentation of the Instrument Society America to offer a concentrated course industrial instrumentation to college ofessors who may be interested in introcing such a course in their own college. may also be of interest to Mechanical gineers. Apparently the reason we have en chosen to offer such a course is that have been teaching a course in Industrial strumentation to Senior Chemical Engiers since 1944, which includes both lecres and laboratory work, and which has en highly successful. Our laboratory is uipped with industrial type instruments illustrate all fundamentals.

The object of this course is not, in any nse, to teach a high-powered mathemati instrumentation course, nor to teach inument repair men; it is to be the same rse taught to Chemical Engineering Senrs to show them the fundamental princis of operation of industrial instruments, d their various characteristics. We feel at this course may be of assistance to er colleges in setting up a similar course their own. We are attaching a syllabus the course showing the subject matter vered in lectures and laboratory. We are so planning two inspection trips to manucturing plants, which we are sure will be ghly interesting. Also, certain of the lecres will be given by representatives of anufacturers.

This course will be available to a limited number of men, and will be given starting Monday, June 14, 1948 and ending July 2, 1948. The registration fee for the course is $35.00. Living accommodations will be arranged for at a fraternity house at a cost for room and board of $25.00 per week; (the course runs for three weeks).

If you are interested in sending one of your instructing staff to take this course, please make application at once, giving the name of the man and enclosing the $35.00 registration fee. Applications will be accepted in the order received, and a preliminary survey indicates that they may greatly exceed the maximum allowable number.

ERNEST D. WILSON, *Head, Department of Chemical Engineering & Chemistry, Worcester Polytechnic Institute, Worcester 2, Mass.*

Outline of Industrial Instrumentation Course

(Sponsored by the Committee on Education of the ISA)

LECTURES

I. Pressure
II. Differential Pressure
  (a) Fluid Measurement.
    (1) Differential pressure producers.
    (2) Differential pressure measures.
  (b) Liquid Level.
III. Temperature
  (a) Filled Thermal Systems.
  (b) Thermoelectric Pyrometers.
  (c) Resistance Thermometers.
  (d) Optical Pyrometers.
  (e) Total Radiation Pyrometers.
IV. Humidity Measurement.
  (a) Wet and Dry Bulb.

(Continued on page 472)

Who's Who in the I. S. A.

RALPH R. BATCHER
(Director, New York Section)

Ralph R. Batcher is now executive editor for the engineering magazines in communication and electronic fields: "Tele-Tech" and "Electronic Industries and Instrumentation." At present, he is President of the New York Section and Chairman of the Publications Committee of the I.S.A. A pioneer author in radio and electronics, Mr. Batcher's published books include "Cathode-Ray Oscillography," "Electronic Control Handbook" and "Electronic Engineering Handbook." Engaged in much earlier research work on television and facsimile during World War I, he became a radio inspector for the Department of Commerce and later instructor in radio theory at the College of the City of New York and at the old Marconi Institute.

After graduating from Iowa State in 1920, until 1924, he was design engineer for the Western Electric (now Bell) Laboratories on machine switching systems, later becoming research engineer for A. H. Grebe & Co., and chief engineer for its pioneer broadcast station WABC. In 1935 he became chief engineer for the A. D. Cardwell Mfg. Co. He is a member of the board of editors of the Proceedings of the IRE, Fellow of the Radio Club of America and a member of Tau Beta Pi.

His wartime developments included pioneer work on the BC-211 Frequency Meter, and a full-automatic precision calibrator for it which read, recorded and typed out in books some 12,000 five place accuracy dial readings per hour. This calibrator was instrumental in saving a few hundred man-years of time during critical production periods.

Currently, he is engaged as consultant in industrial electronics, facsimile and television fields, holding a professional engineering license in New York State.